DOCUMENT RESUME

ED 239 104 CE 037 997

TITLE	Building Trades. Block II. Foundations.
INSTITUTION	Texas A and M Univ., College Station. Vocational Instructional Services.
SPONS AGENCY	Texas Education Agency, Austin. Dept. of Occupational Education and Technology.
PUB DATE	83
NOTE	321p.
AVAILABLE FROM	Vocational Instructional Services, Texas A and M University, F.E. Box 182, College Station, TX 77843 ($7.00).
PUB TYPE	Guides - Classroom Use - Guides (For Teachers) (052)
EDRS PRICE	MF01 Plus Postage. PC Not Available from EDRS.
DESCRIPTORS	Behavioral Objectives; Blueprints; *Building Trades; *Carpentry; Construction (Process); Curriculum Guides; Learning Activities; Lesson Plans; Planning; Postsecondary Education; Secondary Education; Site Development; *Structural Elements (Construction); Trade and Industrial Education

ABSTRACT

Twelve informational lessons and eleven manipulative lessons are provided on foundations as applied to the building trades. Informational lessons cover land measurements; blueprint reading; level instruments; building and site planning; building site preparation; laying out building lines; soil preparation and special evacuation; concrete forms; concrete reinforcement; cement/concrete; concrete mixes and mixing; and placing, finishing, and curing cement. Each informational lesson consists of an instructor's plan (aim, materials, references, prerequisites, a content outline with preparation/motivation, presentation of information, application/student activities, verification and/or evaluation, summary, suggested reading), information sheets, and assignment sheets. Manipulative lessons cover these topics: establish and/or check property boundary lines; establish preliminary building lines and mark for clearing; establish temporary bench mark; set grade stakes; lay out building lines and erect batter boards; prepare subbase for slab and beam foundation; erect forms for slab and beam foundation; erect forms for foundation footing, footing, and wall foundation; set and tie reinforcing steel; and place and finish concrete. Each manipulative lesson consists of an instructor's plan (aim, tools and equipment, materials, teaching aids, checking standards, an outline with preparation/motivation, presentation of skills, application, verification and/or evaluation, summary, suggested reading), job sheets, and task sheets. (YLB)

****
* Reproductions supplied by EDRS are the best that can be made *
* from the original document. *
****

TX8313303

ED239104

BUILDING TRADES

BLOCK II
"FOUNDATIONS"

DEVELOPED
BY
VOCATIONAL INSTRUCTIONAL SERVICES
VOCATIONAL INDUSTRIAL EDUCATION
TEXAS A&M UNIVERSITY

IN COOPERATION WITH
TEXAS EDUCATION AGENCY
OCCUPATIONAL EDUCATION AND TECHNOLOGY
VOCATIONAL INDUSTRIAL EDUCATION

CE037997

U.S. DEPARTMENT OF EDUCATION
NATIONAL INSTITUTE OF EDUCATION
EDUCATIONAL RESOURCES INFORMATION CENTER (ERIC)
☑ This document has been reproduced as received from the person or organization originating it.
☐ Minor changes have been made to improve reproduction quality.
- Points of view or opinions stated in this document do not necessarily represent official NIE position or policy.

(Printed 1983)

"PERMISSION TO REPRODUCE THIS MATERIAL IN MICROFICHE ONLY HAS BEEN GRANTED BY

TO THE EDUCATIONAL RESOURCES INFORMATION CENTER (ERIC)."

Available From

VOCATIONAL INSTRUCTIONAL SERVICES
VOCATIONAL INDUSTRIAL EDUCATION
F. E. BOX 182
TEXAS A&M UNIVERSITY
COLLEGE STATION, TEXAS 77843

All Rights Reserved

by

Vocational Instructional Services
Texas A&M University

MAJOR BLOCK II - FOUNDATIONS

TABLE OF CONTENTS

II-A-1(I) Land Measurements 1
  II-A-1(IS) The Rectangular System of Land Measure 9
  II-A-1(AS) Land Measurement 13
II-A-2(I) Blueprint Reading for Building Trades 17
  II-A-2(IS) Reading Architectural Drawings and Blueprints 33
  II-A-2a(IS) Building Specifications 41
II-A-3(I) Builder's Level, Transit Level, and Equipment 45
  II-A-3(IS) Level Instruments; Their Use and Care 55
II-A-4(I) Building and Site Planning 67
II-A-5(I) Building Site Preparation 73
II-A-1(S) Establish and/or Check Property Boundary Lines 77
  II-A-1(J) Establish and/or Check Property Boundary Lines 87
  II-A-1(TS) Establish P. O.B. (Point of Beginning) 89
  II-A-1a(TS) Set Up and Level Instrument 91
  II-A-1b(TS) Shoot Property Closure 93
II-A-6(I) Lay Out Building Lines 95
II-A-2(S) Establish Preliminary Building Lines and Mark for Clearing 103
  II-A-2(J) Establish Preliminary Building Lines; Mark for Clearing . 109
II-A-3(S) Establish T. B. M. (Temporary Bench Mark) 111
  II-A-3(J) Establish T. B. M. (Temporary Bench Mark) 115
II-A-4(S) Set Grade Stakes 117
  II-A-4(J) Set Grade Stakes 127
  II-A-4(TS) Lay Out and Stake Grid System 129
  II-A-4a(TS) Shoot Existing Grades 131
  II-A-4b(TS) Calculate New Grades; Cut and Fill 133
  II-A-4c(TS) Mark and Set Grade/Guard Stakes 135
II-A-5(S) Lay Out Building Lines and Erect Batter Boards 137
  II-A-5(J) Set Corner Hubs and Erect Batter Boards 149

II-A-5(TS) Set Corner Hubs and Mark Subsidiary Building Corners . . 151
II-A-5a(TS) Erect Batter Boards and Stretch String Lines 153
II-A-7(I) Soil Preparation and Special Excavation 157
II-A-7(IS) Bearing Capacities of Soils. 165
II-A-7a(IS) Classification of Soils by Texture and Structure 167
II-A-6(S) Prepare Sub-Base for Slab and Beam Foundation 169
II-A-6(J) Prepare Sub-Base for Slab and Beam Foundation 177
II-B-1(I) Concrete Forms 179
II-B-1(IS) Concrete Form Construction 193
II-B-1a(IS) Wall Form Design 197
II-B-1(AS) Concrete Forms 205
II-B-1(S) Erect Forms for Slab and Beam Foundation 207
II-B-1(J) Erect Forms for Slab and Beam Foundation 217
II-B-1(TS) Establish Foundation Lines. 219
II-B-1a(TS) Select and Position Form Material 221
II-B-1b(TS) Set and Brace Form Boards 223
II-B-2(S) Erect Forms for Foundation Footing - Footing and Wall Foundation 225
II-B-2(J) Erect Forms for Foundation Footing 235
II-B-2(TS) Locate Building Lines in Excavation. 237
II-B-2a(TS) Install Spacer Stakes and Form Spacers 239
II-B-2b(TS) Set Outside and Inside Form Boards 241
II-B-3(S) Erect Forms for Foundation Walls - Footing and Wall Foundations. 245
II-B-3(J) Construct/Erect Foundation Wall Forms 257
II-B-3(TS) Construct Form Panels 259
II-B-3a(TS) Erect Outside Wall Forms 261
II-B-3b(TS) Erect Inside Wall Forms and Install Form Ties 265
II-E-1(I) Concrete Reinforcement 267
II-E-1(IS) Reinforcing Steel 273
II-E-1(S) Set and Tie Reinforcing Steel - Monolithic Slab and Beam Foundation 277

II-E-1(J) Set and Tie Reinforcing Steel - Monolithic Slab and Beam Foundation 283
II-G-1(I) Cement/Concrete 285
II-G-1(IS) Types of Portland Cement 293
II-G-2(I) Concrete Mixes and Mixing 297
II-G-2(IS) Concrete Mixes 307
II-G-2(AS) Calculate Type, Volume, Cost of Concrete for Jobs Specified 313
II-G-3(I) Placing, Finishing, Curing Concrete 315
II-G-3(IS) Placing, Finishing, Curing Concrete 329
II-G-1(IS) Place and Finish Concrete - Monolithic Slab and Beam Foundations 337
II-G-1(J) Place and Finish Concrete - Monolithic Slab and Beam Foundation 345
II-G-1(TS) Place and Consolidate Concrete 347
II-G-1a(TS) Float Finish Concrete 349

BLOCK II - FOUNDATIONS

REFERENCES

Brinkner, Russell C., Elementary Surveying,
International Textbook Company, Scranton, PA

Dagostino, Frank R., Methods and Materials of Commercial Construction,
Reston Publishing Co., Inc. Reston, VA 22090

Durbahn, Walter E., and Sundberg, Elmer W., Fundamentals of Carpentry,
American Technical Society, Chicago, IL 60637

Lux, Donald G., and Ray, Willis E., The World of Construction,
McKnight & McKnight Publishing Co., Bloomington, IL

Moore, Cairle E., Concrete Form Construction,
Delmar Publishers, Inc., 50 Wolf Road, Albany, NY 12205

*Wagner, Willis H., Modern Carpentry,
The Goodheart-Willcox Co., Inc., South Holland, IL 60473

Watson, Don A., Construction Materials and Processes,
McGraw-Hill Book Co., 1221 Avenue of Americas, New York, NY 10020

White, George R., Concrete Technology,
Delmar Publishers, Inc., 50 Wolf Road, Albany, NY 12205

Woffle, Harvey W., Architectural Drawing,
The Bruce Publishing Co., Milwaukee, WI

* State Adopted Text - V.I.E. Building Construction Trades

II-A-1(I)

INSTRUCTOR'S PLAN
INFORMATIONAL LESSON

SUBJECT: Land Measurements

AIM: The student will be able to read and interpret survey maps and plats, abstracts, and deeds as recorded in the county registry in order to establish and/or locate property boundary lines

TEACHING AIDS: Information Sheet II-A-1(IS), "The Grid System and The Rectangular System of Land Survey"

MATERIALS: Chalk

REFERENCES: Elementary Surveying, Brinker, Russell C., International Textbook Company, Scranton, Pa., Fourth Edition, Chapter 6

PREREQUISITE EXPERIENCE OF THE LEARNER: The student must have successfully completed Major Block I and continue to display an obvious, sincere interest in learning the Building Trades.

I. PREPARATION (OF THE LEARNER - MOTIVATION)

A carpenter often has the responsibility of laying out building lines, establishing grades, and performing other layout jobs requiring a high degree of accuracy. In the layout of a proposed building's lines, the carpenter must locate and/or establish property boundaries. (A sound understanding of land measurement enhances the carpenter's ability to perform these tasks.) Do not take the word of the person selling the property or the neighboring proprietor; although they may be perfectly honest in their beliefs when describing the property boundaries, they may be mistaken. Mistakes that could be costly!

If a recent survey cannot be obtained, the only absolutely sure way is to have a survey made of the property, and to know how to read and interpret it. Getting off to a proper start will save time and expense in the long run.

II. PRESENTATION (OF THE INFORMATION)

INSTRUCTIONAL TOPICS TEACHING POINTS	THINGS FOR STUDENTS TO DO THINGS FOR INSTRUCTOR TO DO OR SAY
A. History	1. Civilized people have always sought means of comparing size; distance 2. Human body was the first measuring stick 3. Early measurements used were: a. Span - the length between tips of thumb and little finger of outstretched hand (approx. 9") b. Cubit - from point of bent elbow to tip

of middle finger of outstretched hand (approx. 18")
    c. Foot - length of foot, toe to heel (12")
    d. Pace - one step (approx. 3 feet)
    e. Fathom - from fingertip to fingertip of outstretched arms (approx. 6 feet)

B. Early Records

1. Egypt was first to record land measurements (surveys)
2. Records of land measurement date back to 1400 B.C.
    a. King ordered the lands of the Nile Valley divided into plots
    b. Plots established farm boundaries for purpose of taxation
3. Early Egyptian surveyors called "rope stretchers"
    a. After their means of measurement
    b. Used ropes with markers at set distances
    c. Rope stretchers were skilled mathematicians
    d. Records are amazingly accurate even by today's standards
4. Later method of measuring land distance was marking rim of wheel and counting revolutions

C. Today

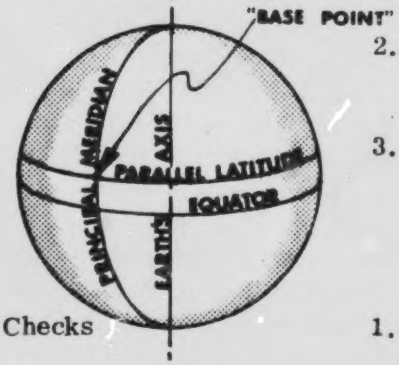
1. Surveys are made to locate and record property boundaries
2. Records are legal documents called deeds
3. Deeds contain legal description of land and properties boundaries
4. Deeds are recorded in county register or county clerk's office
5. Used to settle owners' disputed rights to land
6. Records are free to public examination

D. U.S. System of Land Survey

1. "Rectangular System of Land Measurement" was adopted by Continental Congress in 1785
2. Used by all states except (13) original, Texas, Kentucky, and Tennessee which use a variation or modification of the Rectangular System
3. Reasons these states are not on Rectangular System:

a. Surveys prior to adoption of above system
b. Spanish Land Grants still honored

1. 1. Basis of System



1. U.S. is divided into thirty-five regions for survey purposes
2. Each region has an initial point which serves as a base point for all surveys in that region
3. Base points determined by intersection of:
   a. True north-south lines called "Principal Meridians"
   b. East-west lines of true parallel latitude called "Base Lines"

2. Checks

1. Are 24 mile squares measured from "Base Point"
2. Are identified by lines bounding them
   a. Lines parallel to base line at 24 mile intervals called "Standard Parallels"
   b. Lines parallel to Principal Meridian at 24 mile intervals are called "Guide Meridians"

Note: Guide Meridians are not true north-south line

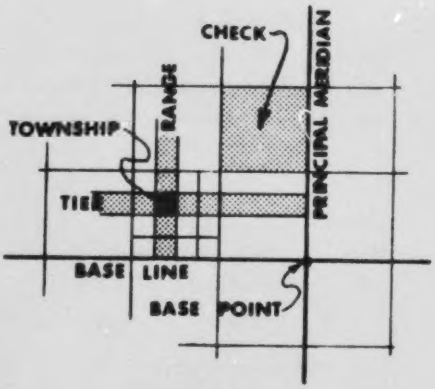
   c. These lines are designated with respect to the base line and the principal meridian

Example: Illustrate on chalkboard

3. Are divided into "townships"

3. Townships

1. Each is 6 miles square
2. Number sixteen to a Check
3. Boundaries are square and normal with standard parallels and guide meridians
4. "Tiers" are adjacent townships east-to-west
   a. Identified by consecutive numbers north and south of "Base Line"
   b. Number accompanied by an N or S designating north or south
5. "Ranges" are adjacent townships north-to-south
   a. Identified by consecutive numbers east and west of "Principal Meridian"
   b. Accompanied by letter E or W designating east or west



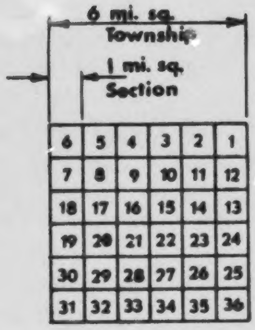
Note: A township is designated by its Tier number, north or south followed by its

Range number, east or west
Example: T3N, R2W. Illustrate on chalkboard

6. Are divided into "Sections"

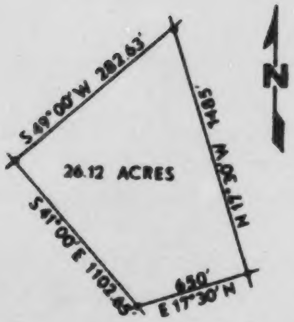
4. Sections

1. Each is one (1) mile square (640 acres)
2. Number 36 per Township
3. Are numbered 1 thru 36
   a. Beginning with northeast section
   b. Reading right-to-left; then left-to-right
4. Sections divided into smaller parcels of land
   a. Half-section (320 acres)
   b. Quarter-section (160 acres)
   c. One-eighth-section (80 acres)
   d. One-sixteenth-section (40 acres)
5. Land identification begins with the smallest unit or parcel to be described
   Example: Illustrate on chalkboard
   NW 1/4, NE 1/4, S1, T3N, R2W, (base point)


6 mi. sq.
Township
1 mi. sq.
Section
6 5 4 3 2 1
7 8 9 10 11 12
18 17 16 15 14 13
19 20 21 22 23 24
30 29 28 27 26 25
31 32 33 34 35 36

E. Texas System

1. Based on U.S. Coast and Geodetic Survey triangulation data computed on the 1927 North American Datum
2. Uses the Lambert Projection of plane coordinates which:
3. Reduces geographic positions and geodetic azimuths of triangulation to plane coordinates and grids
4. Divides state into five zones north-to-south
5. Uses one meridian near the center of each zone as that zone's "Central Meridian"
   a. All north-south coordinates of a zone are parallel to its central meridian
   b. All east-west coordinates are true parallel latitudes
6. Legal descriptions of land are of three types:
   a. Lot and block numbers-used in cities and urban areas
   b. Metes and bounds - "measures and directions" used in rural areas
   c. Government survey - large tracts bound by coordinates, identified by a designated number and zone


S 49°00' W 282.63'
N 17°30' W 1485'
N
26.12 ACRES
S 41°00' E 1102.45'
650'
E 17°30' N

F. Metes and Bounds

1. Means "Measures and Directions"

7

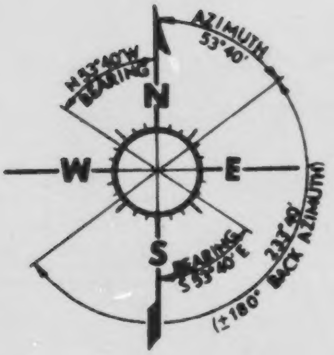
2. Also called a boundary survey
3. Starts at a known (given) point
4. Measures distance and indicates direction
5. Returns to point of beginning
6. Surveyors term this type description a closure, or closed traverse

1. Measures

1. Standard measure in U.S. system of survey is feet, tenths, and hundredths of foot
2. May be converted into these linear measures
   yard .... 3 feet
   rod .... 16 1/2 feet
   chain .... 66 feet, 4 rods
   mile .... 5,280 ft, 1,760 yds, 320 rods, 80 chains
3. Other linear measures honored in Texas
   vara .... 33 1/3 inches
   league......... 5000 varas
   pole, perch .... 16 1/2 feet, 1 rod
4. Measures of area
   1 acre .... 43, 560 sq. ft.
   .... 160 sq. rods, poles
   .... or perches
   .... 10 sq. chains
   1 section .... 640 sq. acres
   .... 1 sq. mile

2. Directions

Note: Although U.S. geodetic surveys calculate true north, considers convergence of meridians and figures angles of deflection, the local surveyor magnetic north adjusted for that area by the Bureau of Land Management. For purpose of discussion we will also use magnetic north



1. Directions are given in terms of an angle generated from, or made with a north-south line
   a. There are 360 degrees in a circle
   b. There are 60 minutes in each degree
   c. There are 60 seconds in each minute
   d. North is established as 0^o
2. Directions are given in terms of degrees, minutes, and seconds
3. Directions are referred to as either
   a. Azimuths
   b. Bearings

II. PRESENTATION (CON'T.)

4. Azimuth is an angle generated from north as 0° in a clockwise direction
   Example: Illustrate on chalkboard
   90° --- due east
   180° --- due south
   270° --- due west
   315° --- northwest
5. Bearing is an acute angle (less than 90°) from either north or south as 0° and either east or west of a north-south line
   Example: N 54° 20'W would be an angle generated from north as 0° to west (counter-clockwise) 54° 21'

III. APPLICATION (DRILL, ILLUSTRATIONS, ANALOGIES, ORAL QUESTIONS OR ASSIGNMENTS, MAKING INVESTIGATIONS OR EXPERIMENTS, NOTE TAKING, MAKING SKETCHES, PARTICIPATING IN DISCUSSION.)

Pass out Assignment Sheet II-A-1(A)
Students complete work assignment as per directions
Class discuss assignment sheet upon completion
Students file in notebooks for reference

IV. VERIFICATION AND/OR EVALUATION (FINAL CHECK ON STUDENTS' COMPREHENSION OF MATERIALS PRESENTED.)

Simple Recall

1.	The U.S. system of land measurement is based on the _____ system of land measure.	Rectangular
2.	The earliest records of land measurement date back to _____ .	1400 B.C.
3.	_____ was the first country to record land measurements.	Egypt
4.	Early surveyors were called _____ after their means of measuring distances.	Rope stretchers
5.	Early recorded surveys of the Nile Valley established farm boundaries for the purpose of _____ .	Taxation
6.	The U.S. system of land survey is based on the _____ system of land measurement.	Rectangular
7.	True north-south lines which pass through a base point are called _____ meridians.	Principle

IV. VERIFICATION (CON'T.)

8.	Lines at 24 mile intervals, parallel to true north south lines are referred to as _____ meridians.	Guide
9.	The division of land 6 miles square is referred to as a/an _____.	Township
10.	A section of land consists of _____ acres.	640
11.	In land identification, adjacent townships east-to-west are referred to as a/an _____.	Range
12.	The point from which all surveys of a given area are taken is called a/an _____ point.	Base
13.	A mile is equal to _____ feet.	5,280
14.	A angle of 140° taken in a clockwise direction from a north line is called a/an _____.	Azimuth
15.	Adjacent townships north-to-south in land identification is referred to as a/an _____.	Tier
16.	A large tract of land 24 miles square is referred to as a/an _____.	Check
17.	There are _____ sections of land in a township.	36
18.	Sections of a township are numbered consecutively beginning in the _____ corner of the township.	Northeast
19.	The direction N 29°31'W is considered a/an _____ by surveyors.	Bearing
20.	A quarter-section of land contains _____ acres.	160
21.	Legal written records of land surveys are called _____.	Deeds
22.	Base lines in the U.S. system of land survey are lines of true parallel _____.	Latitude
23.	A common measurement effected in early surveys of Texas lands was the _____.	Vara

V. SUMMARY (GIVE A BRIEF ACCOUNT OF EACH TOPIC REEMPHASIZING THE IMPORTANT POINTS. THIS SUMMARY MAY BE GIVEN AT ANY PLACE IN THE LESSON THE TEACHER FEELS WILL BE PROFITABLE TO THE STUDENT.)

Earliest written records of land measurement were recorded in Egypt about 1400 B.C. The records established farm boundaries in the Nile Valley for the purpose of taxation.

Since that time land surveys have been made and recorded as legal documents to help identify land and settle land disputes. These records are filed in the county registry or clerk's office and can be an excellent source of information to the surveyor, builder, carpenter.

In 1785 the U.S. adopted the Rectangular System of Land Measurement to identify land holdings for legal purposes. All states except the 13 original, Kentucky, Tennessee, and Texas use this system. Due to surveys made prior to 1785 in these states, that are still recognized and honored, some variation or modification of the Rectangular System is used.

The U.S. is divived into thirty-five regions for survey purposes. Each region has an initial point, "base point", from which all tracts (checks) of land in that region are identified.

These tracts of land are (24) miles square and are divided into (16) townships, each (6) miles square. In turn, each township is divided into 36 sections, (1) mile square. A section of land contains (640) square acres and may further be divided into half-sections, quarter-sections and smaller.

Land parcels are described and/or identified by the smallest parcel first, traced back to the region in which it lies.

Example: (10) acres (metes and bounds description); west half; northwest quarter; northeast quarter; section; township; check; region.

SUGGESTED READING:

Modern Carpentry, Unit 5

The Next Lesson Is: II-A-2(I),"Blueprint Reading for Building Trades"

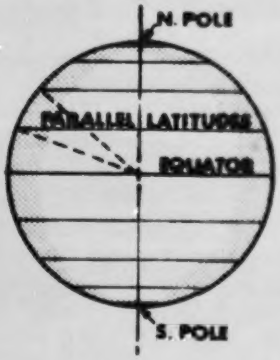
INFORMATION SHEET
ON
LAND MEASUREMENT

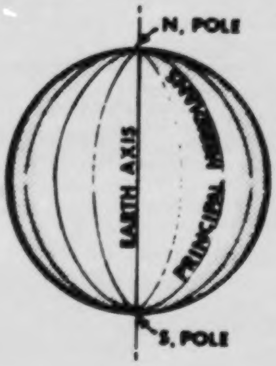
SUBJECT: The Rectangular System of Land Measure

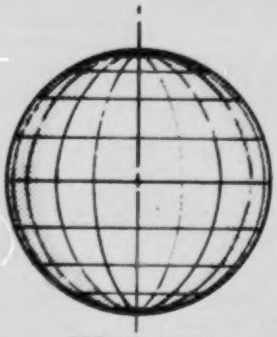
INTRODUCTORY INFORMATION:

Globes, representing the earth on which we live, are the only true maps of the world. Although flat maps are more widely used, certain geographic understandings are more successfully explained using a globe.

On a globe, all parts of the earth's surface appear true to scale, just as they are on earth; therefore, distance and direction can be studied quite accurately using a system of grid lines.







EARTH'S GRID SYSTEM

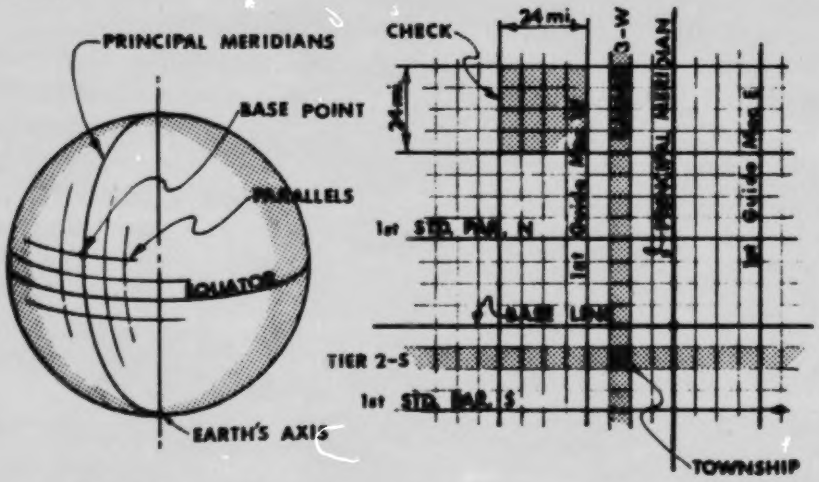
This system is composed of lines of latitude (lines that parallel the equator) and lines of longitude (meridians) that stretch around the earth from pole to pole. With this system of grids the exact location of any place on the earth's surface can be found.

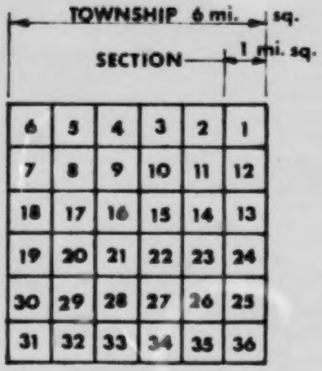
GENERAL INFORMATION

The Rectangular System of Land Measure is an extension of the Earth's grid system. This system was adopted by the Continental Congress of the United States in 1785 as means to survey and record land and property boundaries. It is used by all states except the thirteen original, Tennessee, Kentucky, and Texas. Due to earlier surveys, and the honoring of previous land grants, these states use a variation of the system.

The U.S. is divided into thirty-five regions for survey purposes. Each region has an initial point which serves as a "base point" for all surveys in that region. Each base point is established by the intersection of a true meridian called a "principal meridian" and a true parallel latitude called a "base line". From this point all lands within the region are subdivided into "Checks".

Checks are 24 mile squares measured from the basepoint. Lines bounding these "checks" to the north and south and parallel to the base line are called "standard parallels" and are numbered consecutively to the north and to the south. Lines bounding these checks to the east and the west are called "guide meridians" and are numbered consecutively to the east and to the west. Note that these lines are not true north - south lines but parallel to the principal meridian which is a true north - south line.





6	5	4	3	2	1
7	8	9	10	11	12
18	17	16	15	14	13
19	20	21	22	23	24
30	29	28	27	26	25
31	32	33	34	35	36

Checks are then divided into townships. Each township is six miles square and there are sixteen townships in each check. A township is identified by its "tier" north or south of the basepoint, and its range east or west of the base point. (see illustration)

Townships are further divided into "sections" of land. A regular section of land is one mile square and contains 640 acres. There are 36 sections of land in each township and they are identified by numbers 1 through 36. Starting with the northeast section the numbers read east - to - west (first row), west - to - east (second row), etc.

Sections of land may be broken into smaller parcels of land such as a half-section, quarter-section, etc. Land identification begins with the smallest parcel of land to be described. Urban properties may be identified by lot and block numbers. Normal divisions of rural properties may be described by "size and part" of land sections. Through repeated divisions, some parcels lose their rectangular identity. In such cases they must be described by "metes and bounds" (measures and directions) of the property boundaries. In all cases, the area, in acres, is included in the description.

Example: 40 ac., NW 1/4, NE 1/4, S-28, T3N-R2W, BP7
(40 acres, northwest quarter of northeast quarter, of section 28, of township tier 3 north, range 2 west, base point 7)

The standard measure in the U.S. system of survey is the foot and tenths of a foot. While this measure is most common on survey maps, other forms of measure are frequently used in actual surveys and may appear on maps, in surveyor's field notes, and in the property description of deeds. When carpenters find themselves with the job of checking property boundaries to establish building lines they should be able to read and translate these other measures.

Linear Measure
United States

12	inches	1 foot
3	feet	1 yard
16½	feet	1 rod
320	rods	1 mile
5,280	feet	1 mile
1,760	yards	1 mile

Spanish

Vara of Castile	32.8748	inches
Vara of California	33.372	inches
Legua	5,000	varas
Legua	2.6335	miles
Fanegada	1.5871	acres
Fanegada	69,134.08	square feet

Metric

10 millimeters	1 centimeter
10 centimeters	1 decimeter
10 decimeters	1 meter
1,000 meters	1 kilometer

Gunter's Chain

1 chain	100 links
1 chain	4 rods
80 chains	1 mile
10 square chains	1 acre

Conversion Table

1 chain	66	feet
1 chain	20.1168	meters
1 link	7.92	inches
1 link	0.66	feet
1 foot	0.3048	meters
1 inch	2.54	centimeters
1 meter	3.28023	feet
1 centimeter	0.3937	inches

ASSIGNMENT SHEET
IN
BUILDING TRADES

SUBJECT: Land Measurement

AIM: The student will be able to read and interpret survey maps and calculate simple land areas according to the Rectangular System of Land Measurement.

INTRODUCTORY INFORMATION: Land identification, in the Rectangular System of Land Measurement, begins with the smallest parcel of land to be described. Normal divisions of land may be described by "size and part" of a section. Small parcels, through repeated divisions, may lose their rectangular identity in which case it must be described by "metes and bounds", or "measures and directions" of the property boundaries. In both cases the area, in acres, is always included in the description.

REFERENCES: Information Sheet II-A-1(IS), "Land Measurements"

QUESTIONS AND/OR PROBLEMS: Use the drawings on the following page, assume the base point to be 17.

1. Identify the township in figure A (shaded intersection) by tier, range, and base point. ____________________
2. Identify shaded sections within the township, figure B, by correct number.

   A. ____________ D. ____________

   B. ____________ E. ____________

   C. ____________ F. ____________
3. Identify (describe complete) the parcels of land labeled alphabetically in figure C.

   G. ______________________________

   H. ______________________________

   J. ______________________________

   K. ______________________________

   L. ______________________________

   M. ______________________________

   N. ______________________________

   O. ______________________________

   P. ______________________________

   Q. ______________________________

RECTANGULAR SYSTEM OF LAND MEASURE

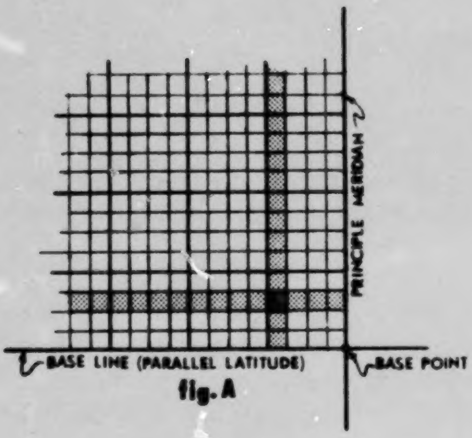

PRINCIPLE MERIDIAN
BASE LINE (PARALLEL LATITUDE)
BASE POINT

fig. A

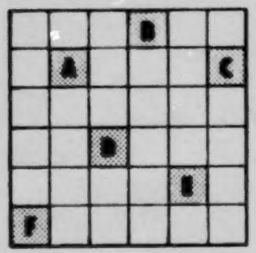
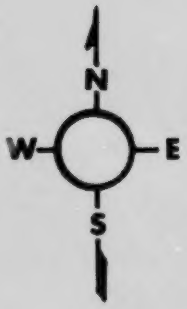


fig. B



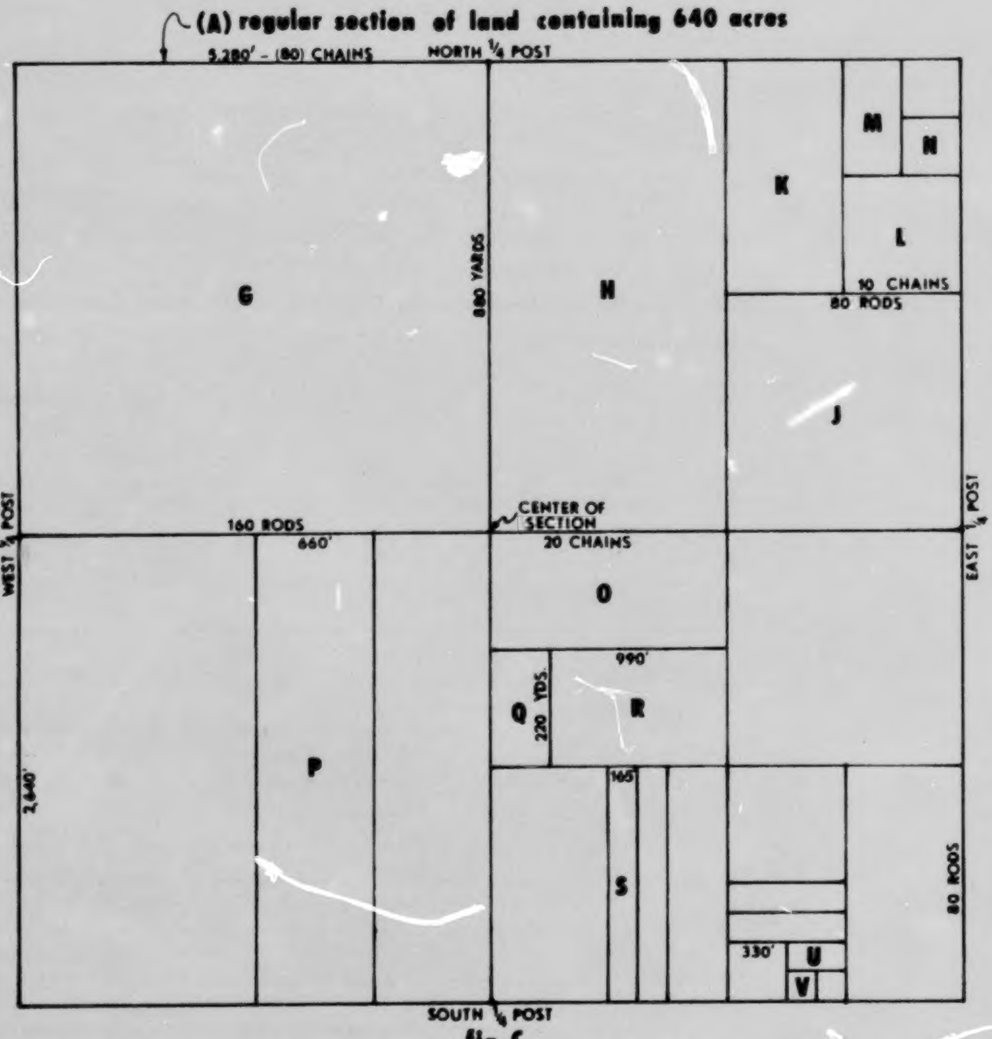

(A) regular section of land containing 640 acres
5,280' - (80) CHAINS
NORTH 1/4 POST
G
880 YARDS
H
K
M
N
L
10 CHAINS
80 RODS
J
WEST 1/4 POST
160 RODS
660'
CENTER OF SECTION
20 CHAINS
EAST 1/4 POST
O
990'
Q
220 YDS.
R
2,640'
P
165'
S
80 RODS
330'
U
V
SOUTH 1/4 POST

fig. C

ASSIGNMENT SHEET
IN
BUILDING TRADES

SUBJECT: Land Measurement

AIM: The student will be able to read and interpret survey maps and calculate simple land areas according to the Rectangular System of Land Measurement.

INTRODUCTORY INFORMATION: Land identification, in the Rectangular System of Land Measurement, begins with the smallest parcel of land to be described. Normal divisions of land may be described by "size and part" of a section. Small parcels, through repeated divisions, may lose their rectangular identity in which case it must be described by "metes and bounds", or "measures and directions" of the property boundaries. In both cases the area, in acres, is always included in the description.

REFERENCES: Information Sheet II-A-1(IS), "Land Measurements"

QUESTIONS AND/OR PROBLEMS: Use the drawings on the following page, assume the base point to be 17.

1. Identify the township in figure A (shaded intersection) by tier, range, and base point. Tier 3, Range 4, Base Point 17
2. Identify shaded sections within the township, figure B, by correct number.

   A. 8
   D. 21
   B. 3
   E. 26
   C. 12
   F. 31
3. Identify (describe complete) the parcels of land labeled alphabetically in figure C.

   G. 160 Ac., NW 1/4, S-8
   H. 80 Ac., W 1/2, NE 1/4, S-8
   J. 40 Ac., SE 1/4, NE 1/4, S-8
   K. 20 Ac., W 1/2, NE 1/4, NE 1/4, S-8
   L. 10 Ac., SE 1/4, NE 1/4, NE 1/4, S-8
   M. 5 Ac., W 1/2, NE 1/4, NE 1/4, NE 1/4, S-8
   N. 2.5 Ac., SE 1/4, NE 1/4, NE 1/4, NE 1/4, S-8
   O. 20 Ac., N 1/2, NW 1/4, SE 1/4, S-8
   P. 40 Ac., W 1/2, E 1/2, SW 1/4, S-8
   Q. 5 Ac., W 1/2, S 1/2, NW 1/4, SE 1/4, S-8

INSTRUCTOR'S PLAN
INFORMATIONAL LESSON

II-A-2(I)

SUBJECT: Blueprint Reading for Building Trades

AIM: The student will be able to read and interpret architectural plans for the purpose of erecting and constructing homes according to the architect's drawings and specifications.

TEACHING AIDS: O.H. projector, Transparencies BT-1-T, Figs.
Blueprint of architectural drawing (obtain from local sources)

REFERENCES: Wagner, Willis H., Modern Carpentry, The Goodheart-Willcox Co., Inc., South Holland, IL 60473, Unit 5
Woffle, Harvey W., Architectural Drawing, The Bruce Publishing Co., Milwaukee, WI

PREREQUISITE EXPERIENCE OF THE LEARNER: The student must have met the course eligibility requirements as set forth by the state and local school administrations, and further display an obvious, sincere interest in learning the building trades.

I. PREPARATION (OF THE LEARNER - MOTIVATION)

Show the students a complete set of architectural plans. Ask the students if they know what they are.

Ask the students to tell you what some of the various symbols represent.

Ask the students to give you the length of an area not directly dimensioned.

Ask the students, "Can you read blueprints ?"

This question is often asked when you are applying for a job. The ability to read blueprints is frequently the basis of promotion for those already on the job. One qualification for all skilled carpenters is the ability to read and interpret architectural drawings.

After the carpenter learns about the tools of the trade, how to use them with skill, and a fair knowledge of the materials worked with, it is essential to be able to read working drawings (blueprints).

After acquiring this skill, the carpenter will be able to work out a series of construction problems; to "take off" dimensions and information accurately and use this information in the construction of a new home.

II. PRESENTATION (OF THE INFORMATION)

INSTRUCTIONAL TOPICS TEACHING POINTS	THINGS FOR STUDENTS TO DO THINGS FOR INSTRUCTOR TO DO OR SAY
A. Architectural Drawings	1. Are a type of communication between the

architect, who envisions and designs a building, and the builder, who sees construction of the building through to finish

Passout: II-A-2(IS)

2. Communicate in the form of technical drawings; graphic representations of a real thing
3. Are made to a reduced scale
   Example: Typical home plan: 1/4" = 1'0"
4. Use various lines and line weights to emphasize or de-emphasize areas of a drawing
5. Use many symbols and abbreviations to identify natural and man made objects
6. Dimension size, shape, and locations in terms of "feet and inches"
7. Descriptive dimensions are in the form of notes, schedules, and specifications

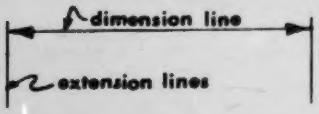
B. Lines and Line Weights

1. Are of three widths (weights)
   - a. Fine (.010")
   - b. Medium (.015")
   - c. Heavy (.020")
2. In approximate proportion are 2:3:4
3. Of same type should be uniform in width
4. Should be sharp and clear
5. Give contrast to the drawing components
6. Used by architects are called "line convention" or "alphabet of lines"
   Note: Illustrate each type line on chalkboard as it is discussed

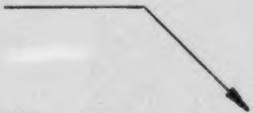
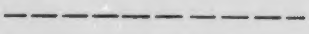
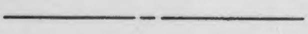
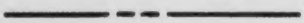
1. Visible Lines

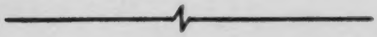
1. Are often called "object lines"
2. Are a heavy (.020") solid line
3. Show the shape of an object
4. Are used to show:
   - a. Outline of building
   - b. Exterior and interior walls and partitions
   - c. Porches, patios, driveways, walks
5. Should be outstanding lines on drawing

2. Dimension Lines

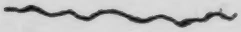


1. Are lines upon which building dimensions are placed
2. Run parallel to the side or part being dimensioned
3. Are a fine (.010") solid line

3. Extension Lines	1. Are extensions of building or object lines 2. Used to set limits for dimension lines 3. Are a fine (.010") solid line
4. Leaders 	1. Are used to connect notes to that part of the drawing they explain 2. Are same weight as dimension lines with arrow pointing to area inferred by note
5. Hidden Lines 	1. Are used to show objects or surfaces not visible 2. Are a medium weight (.015") broken line 3. Are composed of short dashes approx. 1/8" long with 1/32" spaces in between
6. Center Lines 	1. Are used to denote center of object; show symmetry 2. Are a fine (.010") broken line 3. Are composed of long dashes approx. 1 1/2" long alternately with short dashes approx. 1/8" long with 1/32" spaces in between Note: Dashes are approximate and may vary with the size and scale of drawing 4. Are often used to dimension to or from
7. Cutting-plane Lines 	1. Are used to denote an area to be sectioned (cut open) to show inside detail 2. Are very heavy lines (.030") 3. Are composed of long dashes alternately with two short dashes 4. Have arrows at each end pointing in the direction the section is viewed 5. Often only each end of line is drawn to reduce clutter of lines in the area being sectioned 6. Often are identified by letters at the end of lines Example: Line A-A identifies section A-A 7. Often used as match lines of building plans too large for one drawing sheet
8. Break Lines	1. Are used when an area is not shown in its entirety 2. Should not be used if detail is lost or distortion results 3. Are of two types a. Long break line b. Short break line



4. Long break line
   a. Used for long straight breaks
   b. Fine (.010") ruled lines with freehand breaks



5. Short break line
   a. Used for short breaks
   b. Heavy (.020") freehand irregular lines

C. Dimensions

1. Four (4) basic types
   a. Size - overall dimensions
   b. Shape - hips, offsets, etc.
   c. Location - windows, doors
   d. Description - notes and leaders
2. Dimension lines are thin unbroken lines with dimensions placed above the line
3. Dimensions are given in feet and inches
   a. Dimensions over 1' are expressed in feet and inches
   b. Dimensions less than 1' are given in inches only
   c. Fractions are often slashed to conserve vertical space
4. Extension lines set the limits of dimension lines-are an extension of building or object lines
5. Dimension lines are terminated with arrowheads

   Note: Dots may be used in place of arrowheads in confined areas
6. Dimensions may appear on all sides of drawing, but are placed to be read from the right side or bottom of the page
7. Overall building dimensions are placed outside other dimensions
8. Windows and doors, columns and pilasters are dimensioned to their centerlines
9. Windows and doors are usually labeled with a letter; actual size dimensions are found in a window and door schedule
10. Interior dimensions are normally given from wall to wall regardless of wall thickness

    Note: Some architects dimension from exterior of house to centerline of inside wall and partitions
11. Brick and stone veneer dimensions must be added to overall framing dimensions

12. Foundation dimensions must equal overall frame dimension plus brick veneer dimensions
13. Look for enlarged details of areas not covered completely
14. Study all dimensions and notes thoroughly before commencing work

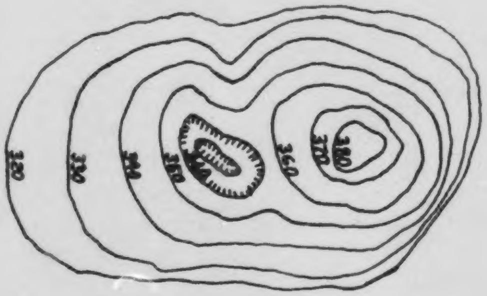
D. Symbols

1. Are simplified pictures of the objects they represent - symbolic representations
2. Are used by architects because:
    a. The real object would be too complicated to draw in detail at such a small scale
    b. A detailed drawing of the object would cause clutter and thereby confuse in the overall drawing
    c. It would be time consuming and expensive to draw in detail
3. Are used in virtually every type of construction drawing to:
    a. Identify objects
    b. Identify materials
    c. Visually locate objects
4. Are easiest identified by first identifying the type of drawing (plumbing, electrical, etc.)
5. Are often accompanied with an abbreviation or special cross reference - look for a drawing legend

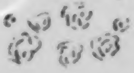
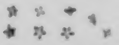
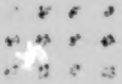
Note: The following symbols should be familiar to the student of building trades. Discuss each symbol in passout as per following example

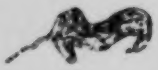
1. Plot Plan Symbols

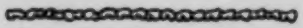
1. Contour lines
    a. Show, in plan, varying land elevations and surface contours
    b. Are fine irregular lines which, if extended over a large enough area, would close (form a loop)
    c. All points on a given contour line are of equal ground elevation
    d. Intervals in elevation between contour lines are constant on any given drawing

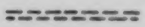


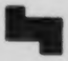
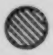
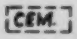
  - e. Successive contour lines evenly spaced indicate the ground slopes uniformly
  - f. Contour lines that suddenly run close together indicate a steep slope or cliff
  - g. Contour lines which spread apart indicate a gradual slope
  - h. At streams, contour lines form V's pointing upstrean
  - i. A contour line forming a small loop with short dashes inside the loops, which extended, converge to loop's center indicates a sudden sink or depression

2. Trees (draw proportionate)
  - a. Broad leaf 
  - b. Conifers 
  - c. Orchard 

3. Lakes and streams (draw proportionate)
  - a. Stream
  - b. Lake 
  - c. Stream and lake

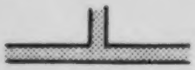
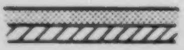
4. Fences
  - a. Barbed wire ——x——x——
  - b. Smooth wire ——o——o——
  - c. Stone 
  - d. Board (other)- - - - - - - - - - - - -

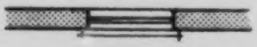
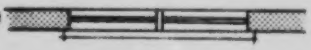
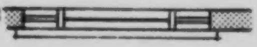
5. Utilities
  - a. Power line -•-•-•-•-•-•-•-
  - b. Telegraph —T————T————T—
  - c. Underground cable or pipe 

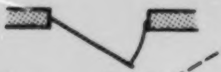
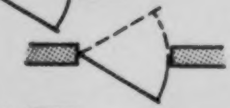
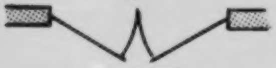
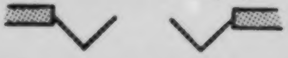
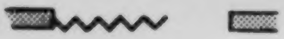
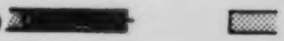
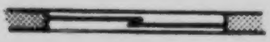
6. Buildings and structures (draw to scale)
   - a. Buildings; homes 
   - b. Tanks, silos, etc. 
   - c. Cemetery, parks 

Note: Lists of symbols not covered may be found in architectural standards and manuals

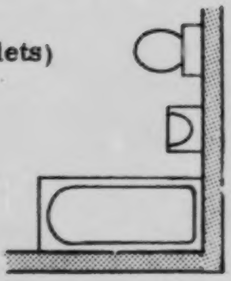
2. Floor Plan Symbols

1. Walls
   - a. Interior, wood frame 
   - b. Exterior w/brick veneer 

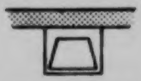
2. Windows (simplified method of drawing)
   - a. Single 
   - b. Double, multiple 
   - c. Picture w/side lights 

3. Doors
   - a. Hinged 
   - b. Double action 
   - c. French (double) 
   - d. Bi-fold 
   - e. Accordian 
   - f. Hidden (pocket) 
   - g. By pass (sliding) 

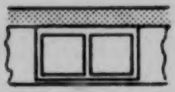
4. Plumbing fixtures
   - a. Water closets (toilets)
   - b. Urinals
   - c. Bath tub



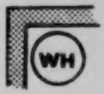
d. Lavatory



e. Sink (double)

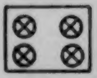


f. Water heater

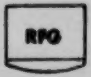


5. Appliances

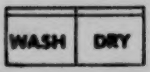
a. Range/oven unit



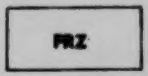
b. Refrigerator



c. Washer/dryer



d. Freezer



Note: Electrical symbols and abbreviations are placed on a floor plan in the area to be located and are not dimensioned

6. Switches (abbreviations only)

a. S, $ single pole switch

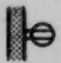
b. S_2 double pole switch

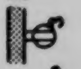
c. S_3 three way switch

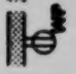
d. S_4 four way switch

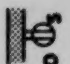
e. S_{wp} weatherproof switch

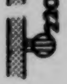
7. Receptacle outlets - are placed on floor plan in area to be located

a.  Duplex outlet

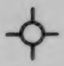
b.  Multiple outlet

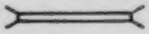
c.  Weatherproof outlet

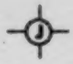
d.  Outlet with switch

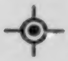
e.  220 volt outlet

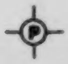
8. Lighting outlets

a.  Basic lighting outlet

b.  Fluorescent light

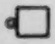
c.  Junction box

d.  Floor outlet

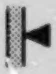
e.  Pull switch outlet

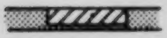
9. Miscellaneous

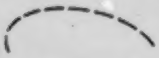
a. Push button

b.  Bell

c. Chime

d.  Telephone

e.  Master power service panel

f.  Switch leg indicator connects lights to switches

E. Specifications

1. Are prepared to insure the building is constructed as planned
2. Are written in or included as an integral part of every builder's contract
3. Cover in detail all incidental ideas which cannot be/are not covered in drawings
4. Begin with general statements and conditions and proceed in a systematic way to cover every aspect of particular building
5. Are usually broken into two parts
   a. General specifications
   b. Detailed specifications
6. General specifications - cover contractual agreement and responsibilities
7. Detailed specifications - broken down to specific type of work, or trade, or sub contract
8. Detailed specifications cover the three (3) "M's"
   a. Methods, of construction (includes standards of workmanship)

- b. Materials, kind and quality (see schedules)
- c. Manufacturer, type and finish (see schedules)

F. Reading and Interpreting Blueprints Systematically

1. Read title block
   - a. Title block located in lower right corner of drawing
   - b. Title information tells you what type of drawing it is
   - c. Drawing scale usually noted in title block information
2. Plan drawings are arranged (generally) so that the building front is nearest the reader; the bottom of the drawing
3. Read any general notes which will be in an open space away from drawing
4. Look for legend; schedules
5. Familiarize yourself with the symbols, abbreviations, and cross references
6. Look at overall size dimensions; shape dimensions - these give one a good idea of size regardless of scale

   Note: Remember the rules for dimensioning are also the key to "reading" dimensions
7. Plans are dimensioned on all four sides
8. Dimensions are placed to read from the right side and/or bottom of page
9. Overall dimensions are placed outside all other dimensions
10. Outside dimensions (floor plan) are given from outside of wall frame
11. Inside dimensions may be given from wall-to-wall regardless of wall thickness; may be given from center-to center of wall
12. Windows, doors, columns, and pilasters are dimensioned to their centers
13. Brick and stone veneer dimensions must be added to overall framing dimensions for foundation dimensions
14. Notes and descriptive dimensions are attached to area being described by "leaders"
15. Dimensions are written in feet, inches, and fractions of an inch thusly 16'-8 1/2"
16. Dimensions are written on tops of dimension lines

17. When dimension area is too small, arrowheads may be left off and replaced with a dot connected to the dimension by a leader
18. Dimension lines parallel dimension being given
19. Dimension lines are terminated with arrowheads
20. Extension lines set the limits of dimension lines
21. Extension lines are a projection of a normal building line
22. The swing of doors and windows are shown in plan
23. Height dimensions are given in elevations; wall section details
24. Look for enlarged details of areas not covered by plans or elevations

G. Types of Architectural Drawings

Note: Following drawings are typical of a modern residence

1. Rendering - (optional) is a perspective or pictorial drawing of:
   a. Architect's concept of the completed home as viewed from the exterior
   b. Gives buyer and builder good idea how the finished product will look
2. Plot plan - Bird's eye view; shows
   a. Locating points, bench marks of land
   b. Land boundaries; locating dimensions
   c. Land topography (existing)
   d. New building size and location includes driveway, walks, etc.
   e. Existing utilities

   Note: Building location is dimensioned from property line to outside edge of building
3. Roof plan (optional) often given in conjunction with plot plan. Shows complicated hips, valley roof design
4. Elevations - views (front, rear, sides) of the building as viewed from the exterior normal to that side
   a. Show exterior features of construction
   b. Show required vertical dimensions above/below datum line (usually grade line)

  c. Elevation dimensions read from right of drawing
  d. Levels dimensioned are labeled with a note, term, or abbreviation
  e. Room heights are shown by dimensions from floor line to ceiling line
  f. Depth of footings are dimensioned from grade
  g. Height of doors, windows are dimensioned from floor line to tops
  h. Ridge and eave lines are dimensioned from floor line
  i. Roof pitch is shown by indicating the rise over the run
  j. Heights of chimneys above ridge are dimensioned
  k. Heights of planters and walls are dimensioned from the ground line

5. Foundation plans show plan layout; sections and details for construction
  a. Plan - overall dimensions; locations of drains, other openings; locations of piers, beams, columns and footings
  b. Sections and details are cross referenced with plan; show type construction; dimensions and details to include:
    (1) Earth preparation
    (2) Vapor barriers
    (3) Reinforcement steel - type, location
    (4) Concrete specifications
    (5) Special construction

  Note: Often foundation materials and types are referenced back to detailed specifications

6. Floor plans show dimensions necessary for framing:
  a. Width and length of building
  b. Interior walls
  c. Location of doors and windows; directions in which they open
  d. Position of stairs, fireplace, and planters
  e. Location and position of major fixtures; appliances

   f. Special details

7. Electrical plan is generally an overlay of the floor plan which shows (visually) locations of:
   a. Power panel
   b. Electrical switches
   c. Electrical outlets
   d. Receptacles (location and type)

   Note: Electrical plans are strictly schematic and dimensions are not given. Specifications dictate the number of circuits, circuit loads, size and quality of electrical components

8. Plumbing and gas plans - are very similar in the type of drawing as electrical
   a. Schematic in nature
   b. Shows visual location
   c. Refers to special details
   d. Refers to specifications

9. Air conditioning - similar to above
   a. Locates unit
   b. Specifies type, size of ducts
   c. Provides key dimensions (lengths, directions, reductions)

   Note: All of these drawings may show several sections and/or details for erection or installation

   Examples of special details:
   a. Stairways
   b. Kitchen and bathroom cabinets
   c. Utilities room
   d. Wall sections

10. Framing plans, floor and ceiling, optional; drawn when joists change directions on a given level

---

III. APPLICATION (DRILL, ILLUSTRATIONS, ANALOGIES, ORAL QUESTIONS OR ASSIGNMENTS, MAKING INVESTIGATIONS OR EXPERIMENTS, NOTE TAKING, MAKING SKETCHES, PARTICIPATING IN DISCUSSION.)

Passout assignment (Instructor prepared for individual class situation.)

Have students complete assignment as per instructions

Class discuss contents of assignment

IV. VERIFICATION AND/OR EVALUATION (FINAL CHECK ON STUDENTS' COMPREHENSION OF MATERIALS PRESENTED)

Passout test (Instructor prepared for individual class situation.)

Have students complete test

Students submit complete test to instructor for grade

V. SUMMARY (GIVE A BRIEF ACCOUNT OF EACH TOPIC REEMPHASIZING THE IMPORTANT POINTS. THIS SUMMARY MAY BE GIVEN AT ANY PLACE IN THE LESSON THE TEACHER FEELS WILL BE PROFITABLE TO THE STUDENT.)

Architectural drawings are a type of communication between the designer and the builder and are in the form of technical drawings; graphic representation of the real thing.

Various types of lines and line weights are used in these drawings to emphasize and/or de-emphasize parts of the drawing which is called "line convention". Knowing these lines (the alphabet of lines) and how they are used enables the builder to better read the drqwing.

Architectural drawings are made to a reduced scale (typical home plans 1/4"=1'-0") due to the size of subject of drawing. Therefore, many symbols and abbreviations are used to indicate objects and materials. This prevents clutter on the drawing and lessens confusion in reading a drawing. Lists of standard symbols and abbreviations may be found in most architectural standards and manuals.

Although the drawing is reduced in scale, it is dimensioned full size. Plans may be dimensioned on all sides; however, dimensions are placed to be read from the bottom or the right side of the drawing page. For features not dimensioned in plans, look for sections, enlarged details, notes, schedules, and even specifications.

There are four basic types of dimensions: size, shape, location, and description. Descriptive dimensions are given in form of a note and are attached to the area being described by a leader (a fine line with an arrow pointing to area).

The other types of dimensions are given in feet and inches (16'-4 1/2") These dimensions are written, centered just above dimension lines which run parallel to the side or part being dimensioned and terminate with arrowheads. Extension lines are extensions of building or object lines and set the limits of dimension lines. All lines used in dimensioning are fine, sharp, lines and do not detract from drawing.

Specifications are an integral part of the architectural plans. They are generally in two parts: (1) General Specifications, and (2) Detailed Specifications. General specifications cover contractual agreements and responsibilities. Detailed specifications cover pertinents for each type of work or trade. The general specifications plus the detailed specifications, along with plans and details pertaining to field of work, should be studeid before work commences.

SUGGESTED READING FOR THE STUDENTS:

Wagner, W. H., Modern Carpentry, pp. 43-53
Durbahn and Sundburg, Fundamentals of Carpentry, pp. 26-50

The Next Lesson Is: II-A-3(I),"Builder's Level, Transit Level and Equipment"

INFORMATION SHEET
ON
ARCHITECTURAL PRINT READING

SUBJECT: Reading Architectural Drawings And Blueprints

INTRODUCTORY INFORMATION:

The idea of communicating thoughts from one person to another by means of pictures occurred to even the earliest cave dwellers. When early people were probably still struggling to communicate through a series of guttural grunts, they realized they could convey a thought or an idea by drawing a graphic representation in the earth or on some object. This type of communication grew into a more permanent form as people recorded ideas and events on the walls of caves and large rocks with a series of drawings. There are still examples of this in existence today.

From these early examples of recorded communication, drawings developed along two distinct lines: (1) artistic and (2) technical. Artistic expression sought to describe the aesthetic, philosophic, or other abstract ideas such as emotion. The "artistic" sought to describe the beauty of nature as it existed. Technical drawings were graphic representations of real things; drawings in which symbols represented objects; drawings which sought to convey messages and impart information. Egyptian Hieroglyphics and the Greek Alphabet are products that evolved from this line.

Historically, people are builders. Used extensively to design and plan for construction, the graphic method of representation evolved still another convention of technical drawing — that of architectural drawing. Today's architect would find it almost impossible to design and plan a building without first drawing it on paper. The architect makes many layouts and sketches before arriving at a successful conclusion; one that is based on function, size, cost, and design. Today's architect must have a thorough knowledge of architectural history and its basic principles to be a successful designer.

The builder or worker is not expected to have the same knowledge as the architect; however, he/she is expected to read and interpret the architect's drawings, and being able to visualize what the finished building looks like results from a mastery of blueprint reading. A worker who cannot read blueprints would require someone else to read them and provide him/her with the necessary instructions to do the job. A worker who cannot read blueprints would never win a promotion on the job because he/she cannot progress under his/her own power.

GENERAL INFORMATION:

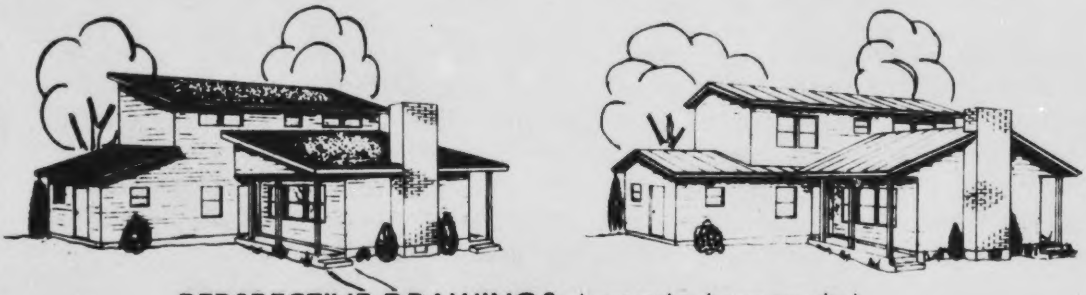
Architectural drawings are a form of technical drawings composed of lines and symbols arranged in such a manner as to provide plans and details for building construction.

In addition to knowing building materials, construction procedures and practices, the builder/craftsperson must be familiar with architectural drawings — the projection methods, line conventions, symbols, and dimensioning practices in order to read and interpret them.

Types of Drawings

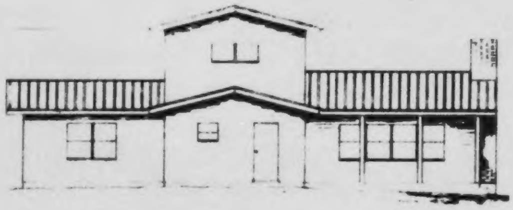
Architectural drawings may be classified according to their kinds of preliminary studies: presentation drawings and working drawings.

"Presentation drawings" are perspective drawings, pictorial illustrations or renderings of what the finished building will look like. This type of drawing is generally used to promote interest in the building; to obtain financiers and investors for development purposes; to promote advance sale or lease before completion. This type of drawing allows the layman (the untrained eye) to see what he/she is getting for the money.

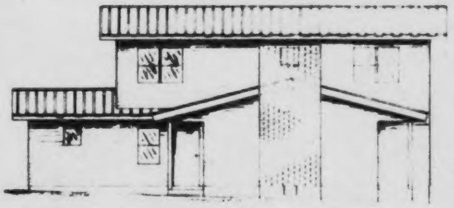


PERSPECTIVE DRAWINGS (two styles for same plan)

"Working drawings" are composed of plans and elevations with areas sectioned and enlarged for detail. These drawings are developed as orthographic projections. This means the object is drawn as the object being viewed would appear if it were projected perpendicularly onto a transparent plane (picture plane) placed squarely between the object and the viewer. This type of drawing shows only the surfaces facing the viewer in true size and shape and shows no depth. The elevation drawings below are orthographically projected and serve well to show exterior style and finish; building and roof outline; and key elevation dimensions.



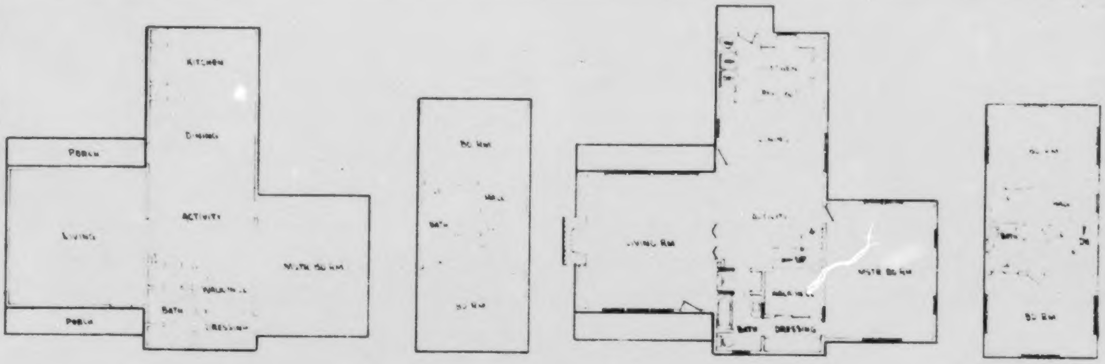
NORTH ELEVATION



WEST ELEVATION

An orthographic projection is ideal for drawing building and house plans in that it readily shows lengths and widths.

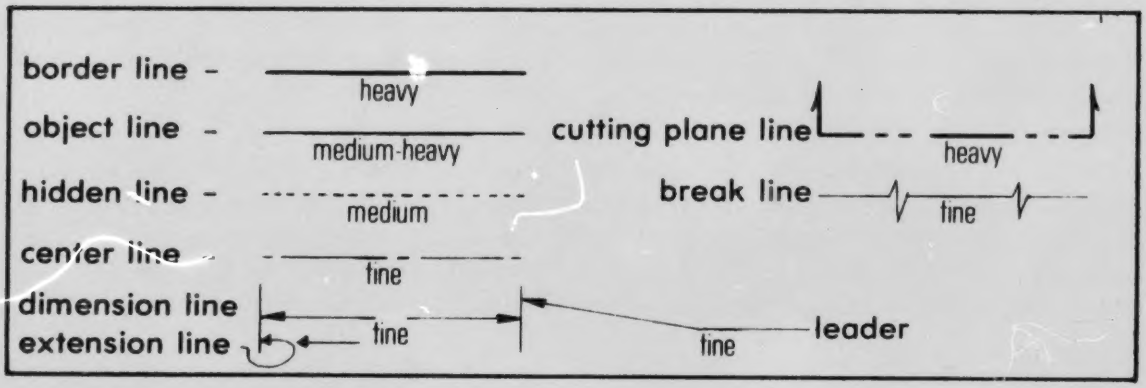
House plans, simply put, are a bird's eye view of a house with the picture plane, or plane of projection parallel to, and approximately 4 feet above, the floor. The roof and upper walls are imagined removed to reveal the floor plan and to locate partition walls, doors, windows, and other major features. The floor plan is the first drawing worked out by the architect and is the key to all other working drawings. From this plan and accumulated design data, the architect develops his foundation plan, framing and roofing plan, electrical plans, plumbing, heating, and air-conditioning plans. Often these special plans are drawn on sepia reproductions of the basic floor plan, adding only the equipment and information necessary for construction and/or installation of that system.


KITCHEN
PORCH
ACTIVITY
PORCH
BATH

BUILDING PLANS

Line Conventions

Each line of a technical drawing carries a specific connotation — a definite meaning. Learning to identify the various types of lines and "their meaning" is the first step in blueprint reading. Each type line has its own identity either by weight or construction, or both. Study these lines and commit their meaning and use to memory.


border line -
heavy
object line -
medium-heavy
hidden line -
medium
center line -
fine
dimension line
extension line
fine
fine
leader
cutting plane line
heavy
break line
fine

The "border line" is exactly what its name denotes. The heaviest line in architectural drawing, it is used to set off borders and title blocks of the drawings.

The "object line," often called visible line, is a medium-heavy, solid line used to show visible outlines or edges of surfaces that would be seen by a person looking at the object, building, or house. This is one of the most important lines because it outlines the main wall lines on plans and elevations and clearly shows the important parts of constructions.

The "hidden line," sometimes called invisible line, is a medium weight line composed of a series of short dashes and is used to show important surfaces and/or edges not visible from the viewer's standpoint. In architectural drawing it is often used to show edges or parts that may be hidden under some other part of the structure, such as hidden piping, wiring, and foundations.

The "center line" (centerline) is a fine line composed of alternate long and short dashes and is used to indicate or denote centers. In architectural drawing it is an accepted practice to locate doors, windows, columns, pipes, even walls by their centers. Dimensions are often given to a centerline.

The "dimension line" is a fine, solid line that is terminated by arrowheads. The dimension line indicates the direction and extent of the dimension given by paralleling the dimension being given. The dimension is indicated by placing it just above and near the center of the unbroken dimension line.

"Extension lines" are fine, sharp lines used as extenders from corners and edges for dimensioning purposes. As major dimensions are placed outside of the object drawn, extension lines set the limits of dimension lines.

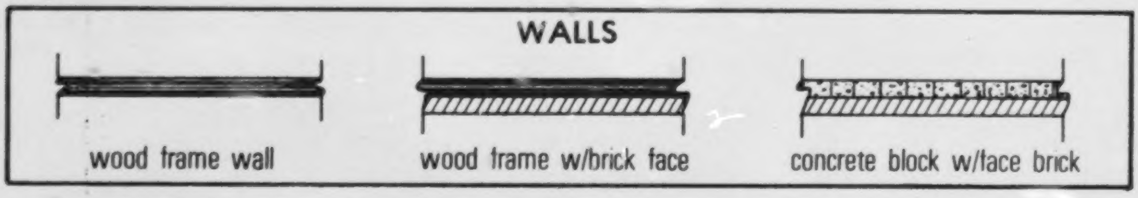
"Leaders" are another form of dimension lines. Leaders are used to point out descriptive dimensions in note form. Leaders are the same weight as dimension lines and terminate with an arrowhead pointing to the part being described.

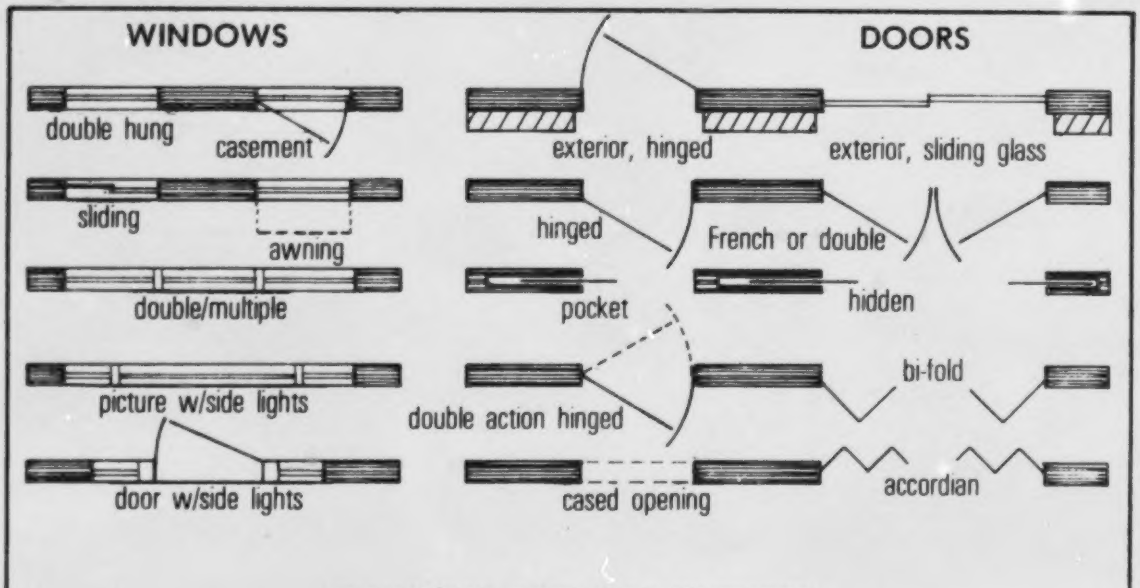
The "cutting-plane line" serves to show where an imaginary cut will be made in an object in order to show internal parts and details. In architectural drawing it is used to show construction and detail of typical wall sections, foundation sections and details, and in large commercial building plans as match lines of plans or elevations requiring more than one sheet of paper for drawing.

The "break line" is used singularly to show that an end section is broken off, or in pairs to show that a middle section is broken out. This line is used to show detail where detail is required and reduce a lot of bulk drawing containing no detail. Note: When a portion is broken out of a drawing, the dimension line carrying that length quite often contains the same squiggly mark as the break line, denoting that dimension is not to scale.

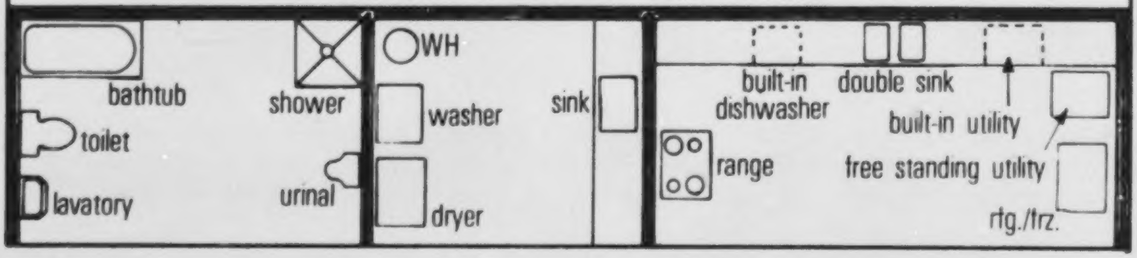
Architectural Symbols

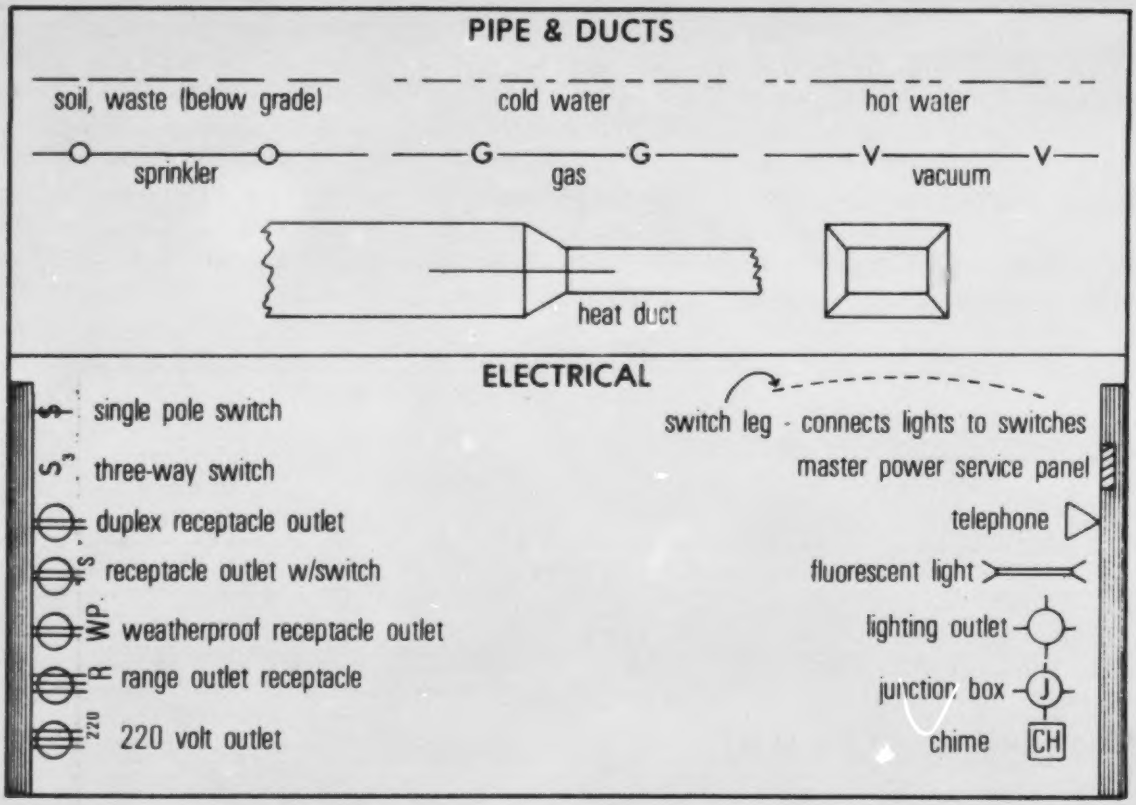
As architectural drafting is a form of technical drawing, symbols are used extensively to represent various components of the architect's plan. Symbols are generally categorized into groups by their application and use. Although the same symbol may vary slightly with the architect's style of drawing, the basic symbol should be easily identified in its context and/or employment. The major groups or categories of architectural symbols are: topographical, used primarily in plot plans; materials, used in elevations and sections; windows and doors; plumbing and gas fixtures, electrical, used in floor plans; and piping and ducts, which may be shown in both plan and elevation depending on the extent and complexity of the job. The following are some of the more commonly used architectural symbols and should be instantly recognized for what they are.


WALLS
wood frame wall
wood frame w/brick face
concrete block w/face brick


WINDOWS
DOORS
double hung
casement
exterior, hinged
exterior, sliding glass
sliding
awning
hinged
French or double
double/multiple
pocket
hidden
picture w/side lights
double action hinged
bi-fold
door w/side lights
cased opening
accordian

PLUMBING AND GAS FIXTURES


bathtub
shower
toilet
lavatory
urinal
WH
washer
dryer
sink
built-in dishwasher
double sink
built-in utility
range
free standing utility
rfg./frz.


PIPE & DUCTS
soil, waste (below grade)
cold water
hot water
sprinkler
G
gas
V
vacuum
heat duct
ELECTRICAL
single pole switch
three-way switch
duplex receptacle outlet
receptacle outlet w/switch
WP
weatherproof receptacle outlet
R
range outlet receptacle
220
220 volt outlet
switch leg - connects lights to switches
master power service panel
telephone
fluorescent light
lighting outlet
junction box
J
chime
CH

Symbols not commonly used and symbols representing special equipment for which there is no standard are generally identified by note or in a legend on the drawing. If a symbol cannot be recognized, reference to the Architectural Graphic Standards or a good architectural drafting text should reveal and identify that symbol.

Dimensions

In dimensioning, the architect provides the builder with the following information about making an object; a house, or a part thereof.

1. The material of which it is to be made which is shown by material symbols and through written specifications.
2. Its shape, which is shown by the drawing itself.
3. Its size, which is shown by dimensions.
4. Locations, also shown by dimensions.
5. Its finish! Shown by notes, specifications, and special instructions.

In no way does the architect attempt to dictate construction processes or procedures. It is the responsibility of the builder to use sound building practices and procedures to produce a strong, durable, and lasting product to the architect's plans and specifications.

In order to better read architectural drawings, the builder should understand some of the rules by which architects dimension drawings. Correct architectural dimensioning practices are as follows:

1. Dimensions are placed outside of the view whenever possible. However, reason allows that a floor plan must have some dimensions inside the view.
2. Dimensions are placed with the use of extension and dimension lines.
3. Extension lines are fine, sharp lines extended out perpendicularly from the ends of the surface, edge, or line being dimensioned. Exension lines set limits of dimension lines.
4. Dimension lines are fine, sharp lines which parallel the surface, edge, or line being dimensioned. Dimension lines terminate with arrowheads at the extension lines. Dimension lines generally carry the dimension above the line near its center.
5. Architectural dimensions are given in feet and inches. Example: 12'–6".
6. Dimensions less than one foot are given in inches only. Example: $8\frac{1}{2}$".
7. Plan dimensions are given from main building lines. In typical frame construction, including brick veneer, this is defined as the outside edge of exterior wall frames – solid masonry is measured from the outside corner.
8. Partition walls, columns, windows, and exterior doors are dimensioned from an exterior wall to their center.
9. Location dimensions may be accumulative. Accumulative dimensions should be in line.
10. When several windows make one large unit, the dimension is to the center of the unit.
11. Windows and doors are identified by a code number. Sizes are found in a window/door schedule.
12. When locations of major plumbing and gas fixtures are not obvious, they are dimensioned to their center. Look to enlarged or special details.
13. Dimensions are placed in a logical sequence equally spaced out from the view.
    a. Location dimensions, usually shorter dimensions such as for doors and windows, are placed first nearest the view.
    b. Shape dimensions, usually moderate in length, such as building offsets, are placed second, outside of the location dimensions.
    c. Size dimensions, such as overall lengths and widths, are placed farthest from the view.

    Note: When dimensions must be placed inside the view, they should be placed clearly and strategically to prevent drawing clutter.
14. All dimensions are placed to be read from the bottom of the page and/or the right side.
15. Key height dimensions are located on elevation drawings.
16. Additional height dimensions are found in sections and details.
17. Sections are noted with cutting-plane line and identified by a letter at each end.
18. Section drawings are labeled by the corresponding letter, thusly "Section C-C".

INFORMATION SHEET
IN
BLUEPRINT READING

SUBJECT: Building Specifications

INTRODUCTORY INFORMATION:

The contract documents of any architectural project are the agreement, the general conditions of the contract, the drawings, and the specifications.

Specifications are prepared to accompany each set of plans.

Specifications begin with general statements and conditions, and proceed in a systematic way to consider the works of the various trades and the materials involved in the construction of the building.

Specifications cover those points of construction that cannot be shown in drawings. Namely, kind and quality of material; manufacturer, type, and finish; method of construction including minimum standards and quality control.

GENERAL INFORMATION:

Specifications guarantee the purchaser that the contractor will deliver the building exactly as specified. Specifications cover every detail explicitly from spelling out legal responsibilities, liabilities, and insurance to the type, quality, and even quantity of nails used.

For this reason specifications are generally broken into two sections; (1) General Specifications, (2) Detailed Specifications. General Specifications cover the broad terms of the contract while Detailed Specifications cover precise qualifications of each type of work, or sub contract.

The following shows major divisions and subdivisions of a typical set of specifications. It will not include specific materials, sizes, or standards, as they vary from job to job and locale to locale.

GENERAL SPECIFICATIONS

Title Page: Specifications for

1. Name of building and name of owner
2. Complete address/location of building
3. Name of architect and/or firm
4. Address of architect and/or firm
5. Architect's seal (official registration of qualifications)

Table of Contents: Quite specific as to where items appear

1. List of all drawings
2. List of all legal documents
3. List of all specifications

Instructions To Bidders:

1. Explanation as to how bid is to be made or presented
2. Time for receiving bids
3. Qualifications of bidders
4. Completion date (time clause)
5. Allowance of payment; alternate materials and methods

Contract Between Owner And Builder:

1. Scope of work included
2. The contract price
3. Signed, sealed, and witnessed

Legal Responsibilities:

1. Applicable building codes and ordinances, adherance to
2. Obtaining and paying for all permits; providing owner certificate of passed inspection
3. Purchase of materials; manufactured items (guarantees of)
4. Insurance during construction - protection against loss, damage; liability; workmen's compensation; social security
5. Quality workmanship, guarantee of work (minimum standards)
6. Manufactured items to be installed according to manufacturer's specifications
7. Rework - responsibility for correction of errors; replacement of damaged goods
8. Responsibility for cleanup
9. Hiring and paying all workers
10. Furnishing all tools and equipment
11. Maintaining time schedules - penalties

DETAILED SPECIFICATIONS

Earthwork:

1. Clearing unwanted growth and objects
2. Disposal method of same - check local ordinances
3. Grading irregularities in soil
    a. Leveling building site
    b. Salvage top soil for later use
    c. Insure natural drainage
4. Excavation according to plans
    a. Earth piles not to interfere with construction; deliveries to site
    b. Excavation kept dry during work progress; free of loose dirt, debris
    c. Backfill, type and amount
5. Finish grade
    a. Redistribute earth, top soil
    b. Clean up, beautification (plant grass, etc.)

Concrete; Cement Work:

1. Foundation size and form; layout and installation
2. Vapor barriers; type and installation
3. Reinforcement; set and tied
4. Concrete, cement mix (poured)
5. Finish of concrete, cement
6. Curing of concrete, cement

Carpentry:

1. Required types and grades of wood
2. List of construction members, sizes, and amounts of wood needed for each job
3. Lists of nail sizes for each job
4. Special woods and applications

Floors:

1. Type, size, and finish
2. Floor covering

Roofing:

1. Type and amount sub roof cover
2. Method to bond cover
3. Type and amount finish roof cover
4. Method to bond cover
5. Guarantees of material and workmanship
6. List of flashing and sizes, roof vents and seals

Insulation:

1. Lists of types, makes, sizes
2. Instructions for installation

Door/Windows:

1. Lists of quantities, types, sizes, material
2. Framing and trim material; finish

3. Weather stripping and caulking
4. Screens; types, location

Interior Walls:

1. Type panel, size manufacturer's model number, color
2. Type size, amount of lath, wire mesh, felt paper, type plaster, number of coats, finish
3. Sheet rock manufacturer, type and size, floating, finish

Electrical:

1. List of all electrical parts: name, type, model number, size, color, and capacity
2. Electrical outlets and their locations
3. Electrical switches and their locations
4. Size and type of wire used
5. Number of circuits and capacity
6. Type, size, model number of panel; location
7. Signed certificate electrical work has passed building inspection

Plumbing:

1. List of all fixtures with makes, color, style, manufacturer, and catalog number
2. List of type and size plumbing lines - gas, water, and waste including vent pipe
3. Instructions for installing and connecting lines (may be drawing)
4. Inspection slips on plumbing
5. Guarantees of plumbing

Air Conditioning:

1. List of all equipment with make, model, color, style
2. Guarantee on all equipment
3. List and location of all duct work to include type, size, insulation, outlets
4. Location of units and instructions for installation and connections
5. Guarantees on all work

Masonry:

1. Location of all stone and brickwork
2. List of size and type stone used, amount
3. Reinforcing steel, type and location
4. Mortar mix
5. Finish

Paint and Finish:

1. List of all paints to be used - color, type, manufacturer, catalog number, and where to be used
2. Preparation of surfaces to be painted; between coat preparation
3. Number of coats
4. Special finishes - types, color, manufacturer, instructions for applying

Miscellaneous:

1. Built-ins locations, dimensions, materials, finishes, hardware
2. Ceramic tile - type, size, color mortar/mastic, locations, instructions
3. Glazing - size, type, glass, instructions for installation

INSTRUCTOR'S PLAN
INFORMATIONAL LESSON

II-A-3(I)

SUBJECT: Builder's Level, Transit Level, and Equipment

AIM: The student will be able to identify the parts of the builder's level and transit level, and explain their function in the use of these instruments.

The student will further be able to explain the use of these instruments as applies to the building trades, and use sound practice and care in handling these instruments and equipment.

TEACHING AIDS: I-A-3(IS), "Transit Level", transit level, tripod, plumb bob, level rod, steel tape, chaining pins

MATERIALS:

REFERENCES: Wagner, W. H., Modern Carpentry, the Goodheart-Willcox Co., Inc., South Holland, IL 60477, pp. 43-51

Durbahn, W. E., Fundamentals of Carpentry, American Technical Society, Chicago, IL 60637, pp. 27-49

PREREQUISITE EXPERIENCE OF THE LEARNER: The student must have successfully completed minor block I-B, "School, Shop Policies and Safety" in addition to previous lessons II-A-1(I) and III-A-2(I), "Blueprint Reading" and "Land Measurements"

I. PREPARATION (OF THE LEARNER - MOTIVATION)

A leveling instrument is a must to the modern day home builder. In building construction it is very important that footings, foundations, and foundation walls be level and square. This provides carpenters and other building trades craftsmen the opportunity to perform their best work with minimal time expended leveling and plumbing.

Leveling instruments are also used to check property boundaries, set grades, and perform other jobs of which a student of building trades should be made aware. In all of these uses, one should be conscious of the rules and procedures regarding the use and care of this equipment as it is one of the most precision and expensive instruments he will use.

II. PRESENTATION (OF THE INFORMATION)

INSTRUCTIONAL TOPICS TEACHING POINTS	THINGS FOR STUDENTS TO DO THINGS FOR INSTRUCTOR TO DO OR SAY
A. Types of Instruments	1. Several types and makes of levels and transits priced from a few hundred dollars to several thousand dollars
	2. Two basic instruments used by builders:

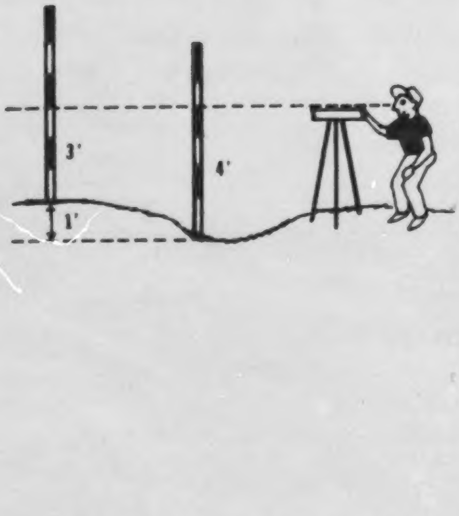
a. Builder's Level - designed to do level work or measure angles only on a horizontal plane
b. Transit Level - performs same functions as builder's level; has additional capacity to measure vertical angles

3. Transit Level a more refined instrument; capable of performing survey work. Also more expensive

B. Uses of Instruments

1. Builder's Level:
   a. Establish levels in relation to a base (datum) point
   b. Determine elevations
   c. Run straight lines; establish points on that line
   d. Layout building lines
   e. Level foundation forms; flooring
   f. Layout and measure horizontal angles
2. Transit Level - all of the above, plus:
   a. Layout and measure vertical angles
   b. Plumb walls and uprights including foundation forms
   c. Establish slopes for tile and drains
   d. Simplifies aligning a row of stakes or a fence running down and up hills

C. Principle of Operation



1. Similar to a carpenter's level - instead of setting on a surface and leveling surface. it is set level and projects a level line
   a. Imagine a carpenter's level fitted with sights and mounted on a tripod
   b. If the level is held so that the bubble is centered in the vial, a sight taken across the length of the level would project a level line

   Note: Sketch illustration on chalkboard

   c. Every point along this line would be in the same elevation
   d. By measuring from this line to the ground at these points, would indicate variations of the ground surface
   e. Ground surface can then be altered and made level. This holds true with floors, foundations, etc.

2. Builder's Level - has same basic function with these additional refinements:
    a. Telescope used for sighting
    b. Adjusting and locking mechanism to level and hold the telescope level
    c. Indexing mechanism - allows scope to be rotated 360° horizontally
    d. Vernier scales to measure angle rotated
3. Transit Level contains all features of the builder's level plus:
    a. Ability to rotate scope vertically
    b. Means of measuring vertical angles

D. Parts and Function
Passout: II-A-3(IS)

1. The Transit Level (Complete instrument) consists of three major sections:
    a. Telescope
    b. Upper body
    c. Lower body
2. Telescope - is similar to a rifle scope. Consists of:
    a. Sealed tube - which contains magnification lens
    b. Adjustable eye piece - to focus cross-hairs
    c. Leveling tube - affixed to telescope to indicate when telescope is level
    d. Sun shield - (optional) on scope end
    e. Telescope focusing knob - objective focus

    Note: Most level tube and cross-hairs have adjustment mechanisms that are factory set and should not be adjusted by the individual
3. Upper body - varies in shape with different makes. All contain:
    a. Means of support for telescope
    b. Indexing mechanism to allow telescope to pivot vertically (transit level only)
    c. Vernier scale to indicate vertical angles
    d. Locking mechanism to hold scope in indicated position
    e. Compass for indicating magnetic north
4. Lower body - attaches to upper body through a horizontal indexing mechanism which allows telescope to pivot 360° horizontally

Contains:
  a. Vernier scales to indicate horizontal angles
  b. Locking mechanism to hold indicated horizontal angle
  c. Base plate with internal threads for attaching to tripod; top machined flat to receive leveling screw feet
  d. Leveling screws for leveling instrument on tripod

E. Instrument Care

1. Always transport instrument in carrying case when moving from one job site to another
2. Place carrying case in vehicle where it will not be subject to jolts, undue vibrations
3. Exercise care when handling instrument, removing and replacing in case, do not hold by scope
4. Place lens covers and tripod cap in carrying case after removing them to prevent loss
5. Return plumb bob to case when moving tripod from station to station
6. Never force or overtighten screws or threads. Finger snugness is the rule
7. Protect lens from direct sun rays. Use lens sunshade at all times
8. Use lens tissue to clean lens; remove dust with camel hair brush
9. Carry instrument, when attached to tripod, under arm with instrument forward
10. Exercise care when moving around set-up instrument; do not leave set-up instrument unattended

F. Related Equipment
  1. Tripod

1. Is the stand on which the instrument mounts
2. Consists of a head and three adjustable legs
3. Tripod head - round, disc shaped metal
   a. Top machined to receive mounting device of instrument
   b. Usually center bored with 3" to 3 1/2" external threads
   c. Threads usually protected by a thread cap
   d. Bottom contains three projections (lugs)

to attach legs

4. Tripod Legs (3) - may be wood or metal
    - a. Usually adjustable in length via slip joint and locking device (clamp screw)
    - b. Attaches to head at lugs by through bolt, lock washer, and wing nut
    - c. Wood legs have pointed metal tip to set firmly in earth surface

2. Plumb Bob
    1. Used to set transit over a station point
    2. Precision machined for balance; resembles a top
    3. Made of brass or steel; brass more popular

3. Level Rod
    1. Used to read differences in elevation between the elevation of the level and various ground or surface levels
    2. Usually consists of two sliding sections so that it may be extended nearly twice its length
    3. About 1 5/8" square when closed and about 6'-6" long
    4. May be extended to 12'-0" length; must be extended completely if extension is used so that graduations are continuous
    5. Graduations are in feet, tenths, and hundredths of a foot
    6. Equipped with a target for easy sighting
        - a. Target tracks on rod
        - b. Held in place by spring clamp

4. Steel Tapes
    1. Referred to as a "chain" by surveyors
    2. Usually mounted on a reel for convenience of handling
    3. Graduations in feet, tenths, and hundredths of a foot
    4. Various lengths; 100' common length
    5. Used for measuring distances

5. Chaining Pins
    1. Often called "tally pins"; come in sets of eleven pins kept on a circular ring
    2. Used to mark ends of measured tape lengths on ground by sticking in ground
    3. Common size is 1/4" diameter x 14" long with eye in one end
    4. Made of steel; painted red and white stripes for easy spotting

G. Set up and Level Instrument

Note: Practice will improve instrument setup time

1. Set up Tripod

1. Loosen tripod wing nuts to ease friction of legs at tripod head
2. Adjust legs to same length approximately 5 feet. This is a temporary adjustment
3. Spread legs 3 to 4 feet with tripod head visually centered over station point

   Note: If ground is unlevel (sloping) place two legs of tripod down slope
4. Readjust legs to visually level tripod head and bring to a comfortable height (chest high)

2. Mount Instrument

1. Remove protective cap from threads of tripod head and store in instrument case
2. Remove instrument from case
   a. Pick up by base to prevent possible damage to telescope
   b. Exercise care in handling not to drop or bump instrument
3. Attach instrument to tripod
   a. Hold in position with one hand
   b. Turn base plate with other hand to engage threads

   Note: Exercise caution not to cross thread or damage threads

   c. Hand tighten base snugly
4. Remove lens, eye-piece covers; store in instrument case
5. Attach sunshade to scope end of tube
6. Attach plumb bob to instrument base through bottom of tripod head
7. Finish centering instrument over datum point by moving legs slightly
8. Set legs firmly in earth surface

3. Level Instrument

1. Release horizontal indexing clamp screw
2. Rotate telescope to be aligned over two of the leveling screws
3. Tighten horizontal indexing screw
4. Face side of scope and level tube
5. Grasp the two leveling screws over which the telescope is aligned between the thumb and forefinger of each hand
6. Rotate both screws in opposite directions at the same time by bringing the thumbs to-

ward or away from each other

Note: The bubble in the level tube will follow the direction of movement of the left thumb

7. Adjust screws until bubble is centered in the level tube keeping leveling screw pads in contact with back of base plate

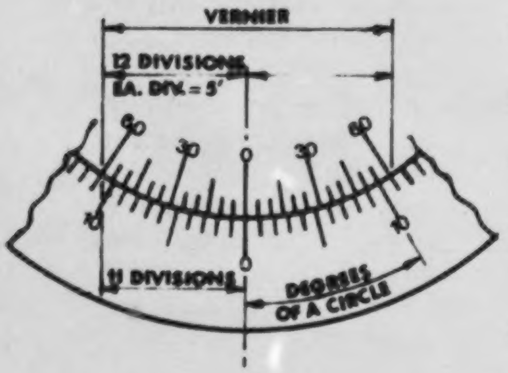
   Note: Level screws should be tightened finger snug. Excessive tightening may cause binding; damage
8. Rotate telescope 90° to be aligned over other two leveling screws
9. Repeat keypoints 4 through 7 above

4. Check Level and Line of Sight

1. Slowly rotate telescope 360° while watching bubble in level tube
   a. If bubble remains centered, telescope is level
   b. If bubble moves off center, telescope is not centered. Re-level!
2. Adjust cross-hair focus
   a. Sight through scope at unmarked object (sky)
   b. Adjust eyepiece to gain sharp image of cross-hairs
3. Adjust objective focus
   a. Sight through scope at some distant object
   b. Turn telescope focusing knob until a sharp image appears in the scope
4. Sight through the scope several directions, to determine if level comes within limits of rod

H\. Read Circular and Vernier Scale

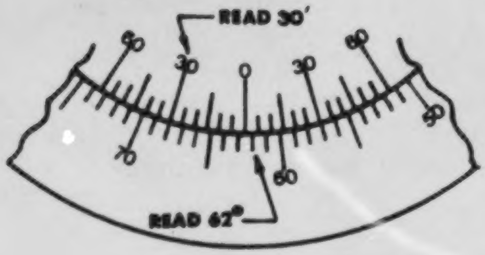
1. Circular scales contain 360 equal graduations
2. Each graduation represents 1° of a circle
3. Most circular scales are divided into four (4) quadrants of 90° each
   a. Start at the top of the circle as a point 0°
   b. Read either direction (clockwise or counterclockwise)
   c. Scale reads from 0° to 90°, left and right sides of circle; back to 0° at bottom of circle
4. Vernier scales allow readings of angles ac-



curately to one-twelfth of a degree, or five minutes

5. The vernier is tangent to, and opposite of the graduations on circular scale
6. Scale is composed of a 0 mark with twelve equal graduations on an arc either side of 0
7. Each graduation on the vernier represents five minutes (5'x12=60' or 1°)
8. A twelve unit arc on the vernier is equivalent to an eleven degree arc on the circular scale
9. Read angles on circular scale
   - a. When "0" mark on vernier aligns with a degree mark on circular scale, an even degree is indicated
   - b. The degree opposite the 0 mark is the angle generated
10. Read minutes on the vernier when "0" mark falls past a degree mark
    - a. Always read in the direction of the increasing angle
    - b. Locate a "five minute" calibration which lines up with a degree calibration
    - c. The minutes are read from "0" to the aligned mark

Example: 62° 30' sketch on chalkboard



III. APPLICATION (DRILL, ILLUSTRATIONS, ANALOGIES, ORAL QUESTIONS OR ASSIGNMENTS, MAKING INVESTIGATIONS OR EXPERIMENTS, NOTE TAKING, MAKING SKETCHES, PARTICIPATING IN DISCUSSION.)

1. Set up instrument in classroom.
   Have students identify different parts of instrument, related equipment and explain their function.
2. Take down instrument, tripod. Put out of adjustment.
   Have students set up tripod, mount and level instrument, and make ready for use over a given point.
   Have students explain procedure; defend procedure.

IV. VERIFICATION AND/OR EVALUATION (FINAL CHECK ON STUDENTS' COMPREHENSION OF MATERIALS PRESENTED.)

1. The two basic leveling instruments used by home builders are the Builder's Level and the _____ Level.	Transit
2. The _____ Level is the more refined of the two instruments.	Transit

3.	The more refined of the two instruments studied has the added capability to lay out and measure _____.	vertical angles
4.	There are _____ degrees in a complete circle.	360
5.	When using the leveling instrument, lens covers should be stored in the _____.	carrying case
6.	_____ scales indicate the angle an instrument is rotated.	Vernier
7.	When adjusting level screws, the bubble in the leveling vial will follow the direction of movement of the _____ thumb.	left
8.	A sunshade is used on the telescope to protect the _____ from direct sun rays.	lens
9.	Carry an instrument mounted on the tripod under arm with the instrument _____.	forward
10.	Precision machined for balance, the _____ is used to accurately set the instrument over a station point.	plumb bob
11.	The _____ is used to read differences of elevation between the height of the instrument and ground surfaces.	level rod
12.	Steel tapes used for measuring distances are referred to by surveyors as _____.	chains
13.	Another name for chaining pins is _____.	tally pins
14.	The rule on tightening instruments threads is _____ .	finger snug
15.	The cross-hair of the telescope is brought into focus by adjusting the _____.	eyepiece

V. SUMMARY (GIVE A BRIEF ACCOUNT OF EACH TOPIC REEMPHASIZING THE IMPORTANT POINTS. THIS SUMMARY MAY BE GIVEN AT ANY PLACE IN THE LESSON THE TEACHER FEELS WILL BE PROFITABLE TO THE STUDENT.)

A leveling instrument is vital in building construction in many ways. It is used to check property boundaries, set grades, establish building lines, and level foundation forms and floors.

The two basic instruments used in construction are the Builder's Level and the Transit Level.

The Transit Level, in addition to performing all the tasks of a builder's level, has the capacity to set and measure vertical angles. This is a valuable asset in that it simplifies plumbing foundation forms and walls. Also may be used to survey.

The leveling instrument operates on the principle of projecting a straight, horizontal line in any direction. By using related equipment (level rod, chain, and tally pins) variations in elevation of ground surface in relation to the instrument height can be obtained at any point on this "line of sight' and distances measured and marked.

Proper care in handling and use of these instruments is essential if consistent, accurate work is to be accomplished. Instrument screws and threads should never be forced or overtightened; finger snug is the rule. The telescope lens must be given special care. Use sunshade at all times set up, lens covers when stored, lens tissue for cleaning. In handling, storing, and transporting, these instruments should be afforded the attention given any precision tool.

SUGGESTED READING FOR THE STUDENT:

Wagner, W. H., Modern Carpentry, Units 3 and 6

The Next Lesson Is: II-A-4(I), "Building and Site Planning"

INFORMATION SHEET
ON
THE BUILDER'S LEVEL, TRANSIT LEVEL, AND EQUIPMENT

SUBJECT: Level Instruments; Their Use and Care

INTRODUCTORY INFORMATION:

Level instruments, used properly, provide carpenters and other building trade crafts the opportunity to perform their best work with minimal time expended leveling and plumbing.

In building and construction "leveling" is used extensively to establish and/or verify existing topographical data of building sites; compute requirements necessary to correct topographical conditions to conform with design specifications; set controls and establish new elevations for construction purposes. Simply stated, this means "determine existing grades; calculate necessary cut and fill; establish new grades and elevations for construction purposes."

There are many types and makes of level instruments which vary considerably in design, cost, and accuracy. All are precision measuring devices that operate on the principle of projecting a straight, horizontal line of sight in any direction. The difference lies in the power of the telescope, the acuteness with which angles can be read, and the ability to perform additional functions.

The two instruments most commonly used in building trades are the Builder's Level and the Transit Level. Both are similar in function, setup, and operating procedure.

GENERAL INFORMATION:

Uses of Level Instruments

The Builder's Level is used to:

1. Establish levels in relation to a base (datum) point
2. Determine existing elevations
3. Set grade stakes and future (potential) elevations
4. Run straight lines and establish points on a line
5. Lay out and measure horizontal angles of any degree
6. Lay out lines
7. Level foundation forms; flooring

The Transit Level can perform all of the above in addition:

1. Establish slopes for tile and drainage
2. Plumb walls and uprights
3. Measure Vertical angles
4. Perform complete survey

Parts of Builder's Level

Consists of three major sections: telescope, upper body, lower body.

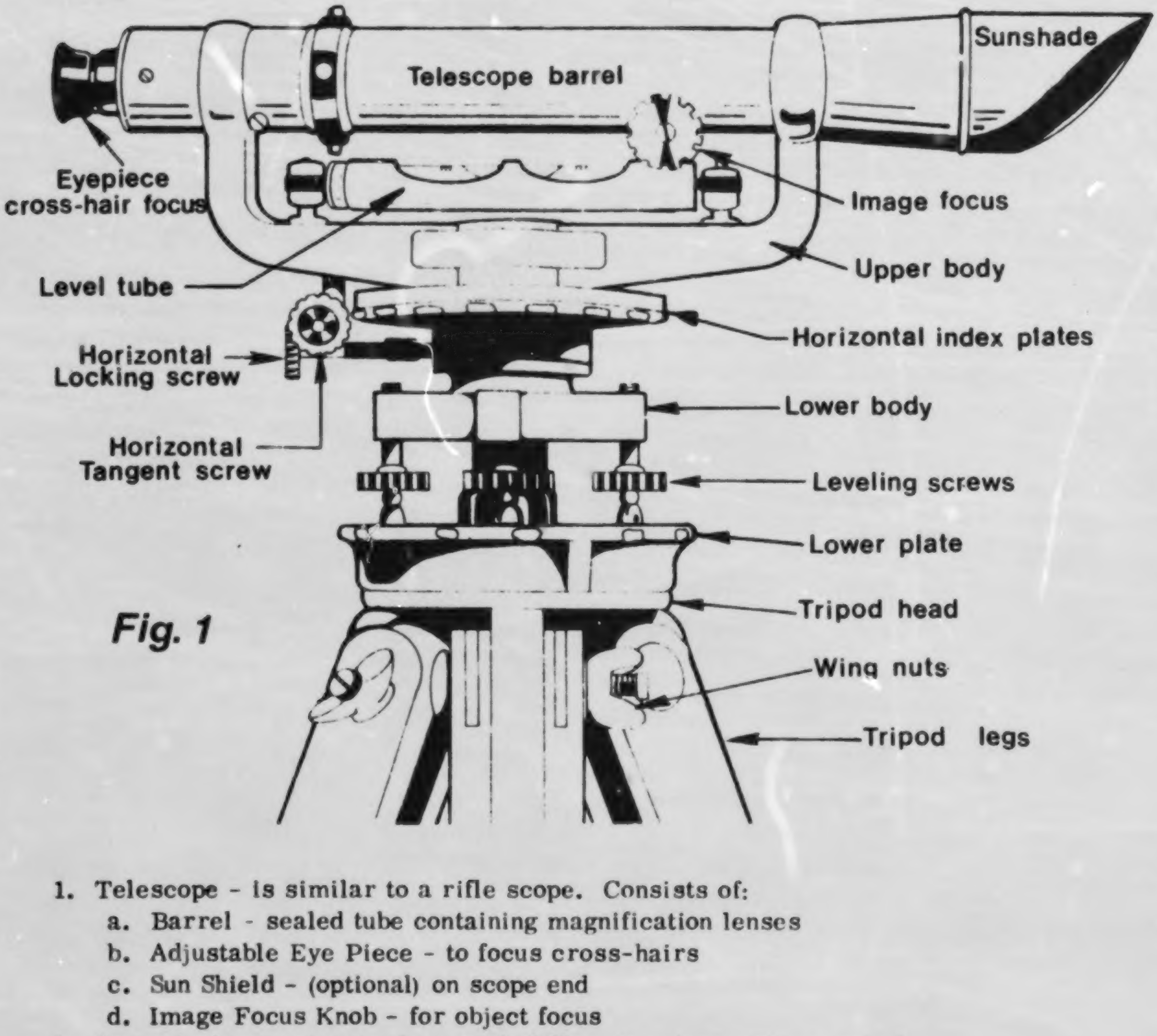

Sunshade
Telescope barrel
Eyepiece cross-hair focus
Image focus
Upper body
Level tube
Horizontal index plates
Horizontal Locking screw
Lower body
Horizontal Tangent screw
Leveling screws
Lower plate
Tripod head
Wing nuts
Tripod legs

Fig. 1

1. Telescope - is similar to a rifle scope. Consists of:
   a. Barrel - sealed tube containing magnification lenses
   b. Adjustable Eye Piece - to focus cross-hairs
   c. Sun Shield - (optional) on scope end
   d. Image Focus Knob - for object focus
2. Upper body - varies in shape with different makes. Composed of:
   a. Frame - means of support for telescope
   b. Upper Plate - horizontal indexing; contains vernier for reading angles; is supported by tapered center which pivots inside concentric center of lower plate
   c. Level Tube - spirit level; may be attached to telescope or upper body
   d. Horizontal Motion Clamp Screw - clamps upper, lower plates together
   e. Horizontal Motion Tangent Screw - used for fine adjustment

3. Lower Body - Includes:
    a. Lower Plate - horizontal indexing; contains circular graduations (degrees); affixed to tapered center of lower body
    b. Level Head - integral part of lower body; contains leveling screws
    c. Leveling Screws - used to level the instrument
    d. Base Plate - provides uniform surface to receive bearing pressure from leveling screws; contains internal threads for attaching to tripod head
4. Tripod - stand on which instrument is mounted; consists of
    a. Head - ring shaped disc with external threads to mount instrument, and three lugs machined to attach legs
    b. Legs - (3) attach to tripod head at lugs by machine bolts and friction nuts (wing nuts)

Instrument Care

Level instruments are precision measuring devices which must be handled and transported properly if they are to provide lasting and accurate service. The following are suggestions for handling and transporting:

1. Always store instrument in carrying case - place in protected area.
2. Always transport instrument in carrying case when moving to and from job sites.
3. Protect instrument from shock and vibrations.
4. Lift from, and return to, case carefully - do not lift or handle by the telescope.
5. Place loose parts (lens covers, thread cap, plumb bob) in case when not in use to prevent loss.
6. Exercise caution when mounting instrument on tripod - do not cross-thread 3½" diameter threads.
7. Never force or overtighten screws or threads. Finger snugness is the rule.
8. Protect lens from direct sun rays - use sunshade as required.
9. Use lens tissue to clean lens; remove dust with camel hair brush.
10. Never remove lens from telescope.
11. Carrying instrument mounted on tripod; tighten (snug) all clamp screws:
    a. In open country - close legs; place on shoulder with instrument back of head; sling forearm over legs.
    b. In brush and trees - close legs; carry under arm with instrument forward, close to body.
12. Set tripod legs firmly before mounting instrument.
13. Exercise caution moving around a setup instrument.
14. Never leave a setup instrument unattended.

Set Up and Level Instrument

1. Set up Tripod
    a. Unbuckle leg strap and ease leg friction at tripod head - turn wing nuts counterclockwise slightly.
       Note: Some friction (stiff movement) is desirable.
    b. Check leg lenghts if adjustable. Adjust legs evenly to approximate 5' long.
    c. Spread legs evenly 3' - 4' apart and position tripod over desired location.

Set legs firmly in ground with head visually level.
Note: If tripod is on sloping ground, position two legs downhill.

d. Tighten wing nuts at tripod head; remove protective cap from head and store in case.

2. Mount Instrument
   a. Remove instrument from case carefully. Do not lift or hold instrument by telescope. Do not bump or drop instrument.
   b. Position instrument base on tripod head to engage threads. Hold instrument steady with one hand; engage threads handtight (snug) with other hand.
      Note: Do not force or cross threads.
   c. Remove lens covers and store in case. Install sunshade.
3. Level Instrument
   a. Loosen horizontal motion clamp screw and rotate telescope to align over two opposing leveling screws. Tighten clamp screw.
   b. Face side of telescope with level tube - turn the two leveling screws aligned with the telescope in opposite directions simultaneously using the thumb and forefinger of each hand.
   c. Observe the bubble in the spirit level. The bubble will follow the direction of movement of the left thumb. Bring the telescope to the level position (bubble centered between the lines on the level tube.)
   d. Loosen horizontal motion clamp screw and rotate telescope 90° to align over opposite two leveling screws. Tighten clamp screw! Repeat steps b and c above.
      Note: To check instrument level, loosen horizontal motion clamp screw and slowly rotate telescope 360°. Observe bubble in level tube - bubble should not move out of center position (from between lines on the level tube).
4. Set Up Instrument Over A Given Point
   a. Set up tripod and mount instrument similarly as in steps one and two - visually leveled and centered over the given point.
   b. Suspend plumb bob on a cord from the plummet at the bottom of the instrument - point of plumb bob very near the level of the given point (nail in top of stake).
   c. Relocate instrument so that plumb bob is not more than $\frac{1}{4}$" horizontally from the exact point by shifting the tripod legs slightly.
      Note: Maintain visual level of instrument - set legs firmly - tighten wing nuts at tripod head upon relocation.
   d. Position plumb bob directly over given point by loosening two adjacent leveling screws and shifting the instrument on the base plate to the desired position. Tighten leveling screws.
   e. Level instrument as per step three.

Leveling

To better understand the principle of leveling, certain terminology should first be studied and committed to memory.

Vertical line - a line to the center of the earth from any point. A line in the direction in which gravity works - a plumb line.

Level surface - a spheroidal surface paralleling the surface of the earth's oceans. (The surface of a body of still water - best example).

Level line - any line in a level surface.

Mean sea level - the average height of the surface of the sea. The standard datum for all elevations throughout U.S. Established by taking hourly readings of all stages of the tide over a 19 year period; called Sea Level Datum of 1929.

Datum - reference to an elevation.

Vertical control - a series of points of known elevation established throughout a project.

Bench Mark (BM) - a permanent material object, natural or artificial, bearing a marked point of known elevation.

Temporary Bench Mark (TBM) - a relatively permanent material object whose elevation is established for a particular job.

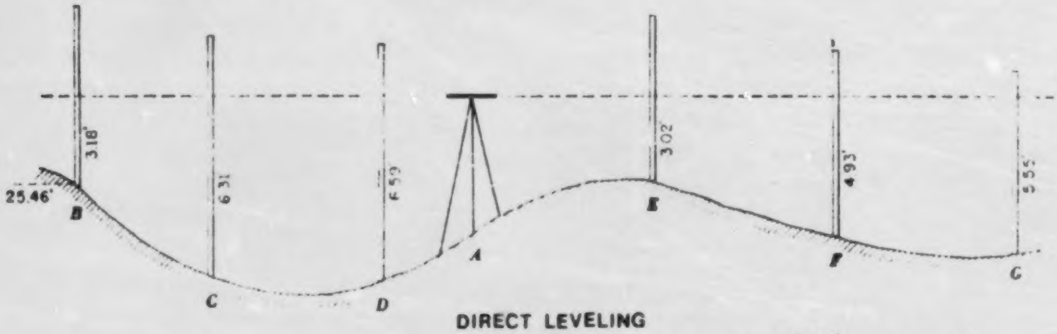
Height of Instrument (HI) - is the elevation at the line of sight of the telescope of a level instrument.

Back Sight (BS) - also called "plus sight" (+S) is the reading on a rod held vertical at a point of known elevation.

Fore Sight (FS) - also called "minus sight" (-S) is the reading on a rod held vertical at a point whose elevation is to be determined.

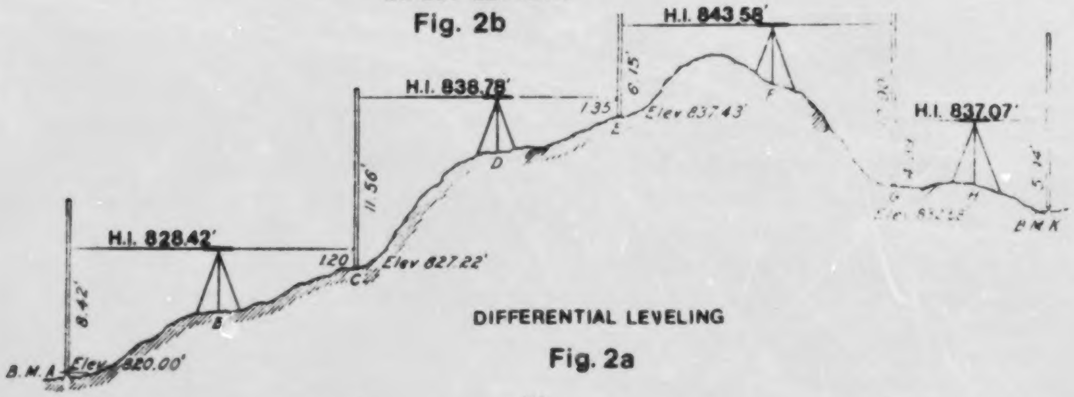
Turning Point (TP) - a stable point, first of unknown elevation, then of known elevation, used to carry forward a line of levels.

Leveling - is the process of determining elevations, or differences in elevations of points. There are several types of "leveling" which are generally named after their function: differential leveling, profile leveling, borrow-pit or cross-section leveling, etc. All leveling operations may be expressed in two equations repeated over and over as necessary.



DIRECT LEVELING

Fig. 2b



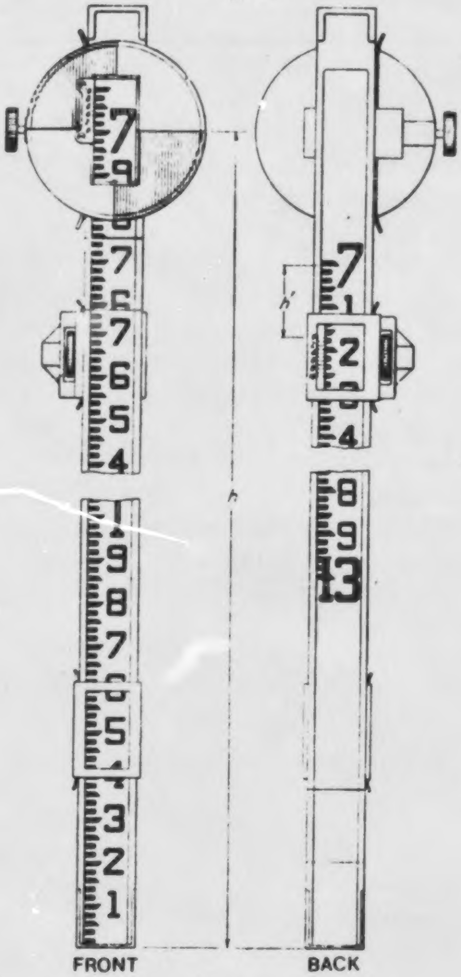
DIFFERENTIAL LEVELING

Fig. 2a

Leveling is performed with the level instrument (mounted on tripod) and the level rod. Leveling requires the coordinated effort of two persons working as a team - communicating through a system of signals. The instrument man sets up, levels, and operates the instrument. He must be able to read the rod accurately and record readings systematically. Leveling rods, generally, are graduated wooden rods. There are several kinds of leveling rods which differ in construction details but not in principle of operation. The two most commonly used are the Philadelphia rod and the California rod.

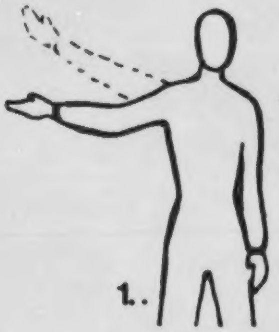
The Philadelphia rod consists of two longitudinal sections held together with brass sleeves and clamps which allow the rear section to slide causing the rod to be extended. The front face of the two sections are graduated in feet, tenths of a foot, and hundredths of a foot. The graduation marks themselves are painted .01' wide with .01' spaces between. The .10' and .05' graduations are emphasized by spurs extending the marks. Tenths are indicated by black numbers, and feet by bolder red numbers centered on their respective marks. When the rod is closed, called a "short rod," heights to 7'-0" can be read. When the rod is extended fully, called a "long rod," the graduations are arranged continuously to read heights to 13'-0". The back of the upper rod is marked from 7'-0" downward to 13'-0 in the same manner as the front. On distant shots a target is set at 7'-0 and the rod raised to the level of the telescope. The target is generally a circular shaped plate painted red and white in alternate quadrants to assimilate the telescope cross-hairs. It contains a window in its center for reading the rod. When the correct level is reached the instrument man signals the rodman who takes the reading through a fixed window on the back attached to the lower rod. A rod partially extended is referred to as an "open rod."

Fig. 3

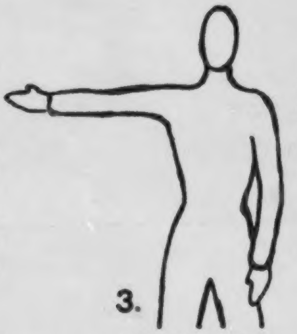


Philadelphia Rod

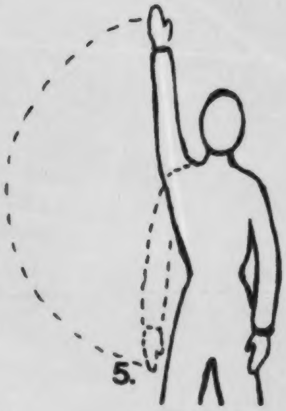
Hand signals are used to communicate instructions between the instrument man and the rodman. Often working several hundred feet apart renders verbal instructions inadequate. As the rod must be plumb with the instrument cross-hairs -- a rod leaning in any direction will cause inaccurate readings--the instrument man must signal instructions to the rodman who positions and holds the rod accordingly. Following are hand signals frequently used.



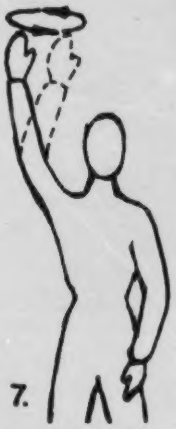
1. RAISE THE TARGET



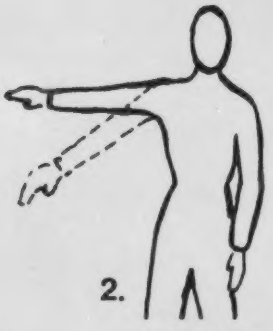
3. MOVE TARGET LEFT



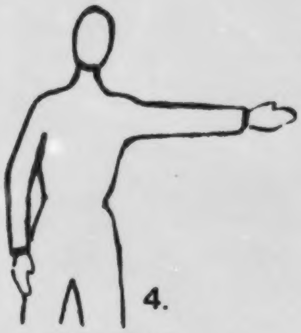
5. PLUMB THE ROD



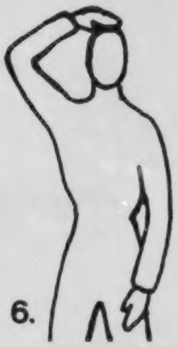
7. HOLD THE POINT



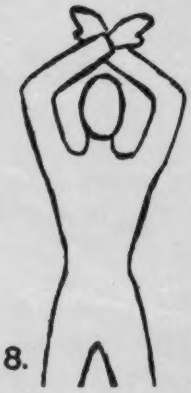
2. LOWER THE TARGET



4. MOVE TARGET RIGHT



6. MOVING THE TARGET



8. OBSERVATION COMPLETED

1. Raise the Target - right arm outstretched to side with palms up; slowly raise arm until target is positioned.
2. Lower the Target - right arm outstretched to side with palm down; slowly lower arm until rarget is positioned.
3. Move Target Left - extend right hand in direction rod is to be moved. A long sweeping motion indicated a long distance; a short quick motion indicates a short distance.
4. Move Target Right - opposite of "move target left."
5. Plumb the Rod - extend either arm above head - move arm slowly in direction top of rod must move to align with telescope vertical cross-hair - stop arm motion when plumb.
6. Moving the Target or Rodman has moved the Target - extend arm up at 45° angle with body and place palm of hand on head (used by rodman).
7. Hold the Point (used to signal the level is going to be moved; the rod must not be

moved until new backsight has been taken) - extend right hand above and wave in a circle.

8. Observation Completed - extend both arms above head and cross.

Shooting And Recording Levels

Certain procedures should be followed when shooting and recording levels in order to produce the most accurate results with least effort.

Direct Leveling - is used in areas where all readings can be taken from one HI setting.

Example: Setting grade stakes on a building site which has a gentle change in topography and is moderate in size.

Procedure:

1. Study the job at hand! From blueprint plot plans:
   a. Study grade contours and topography. Note contour elevations; topographical features which may obstruct vision.
   b. Locate BM, potential TBM, best location to set up level.
   c. Determine grid system for setting grade stakes; size of plot; spacing of grids.
   d. Make grid drawing on plot plan or plot plan overlay to same scale. Locate and identify all grid intersections.
2. Lay out and stake grid system according to drawing:
   a. Locate property rront boundary or other base line for grids - lay out grid intervals as per grid drawing - set 2" x 2" x 6 lg. stake flush with ground at each point.
   b. Lay out perpendicular line to base and set grid stakes similar as base line.
   c. Lay out intermediate grid points using intersecting tapes from appropriate points and mark with stakes as others.
3. Set up instrument at chosen station point:
   a. Visually check lines of sight - to BM or TBM, to distant points of plot.
   b. Set up and level instrument.
   c. Recheck lines of sight using telescope and level rod (adjust station point as necessary).
   d. Establish HI and record.
4. Shoot elevations systematically and record.

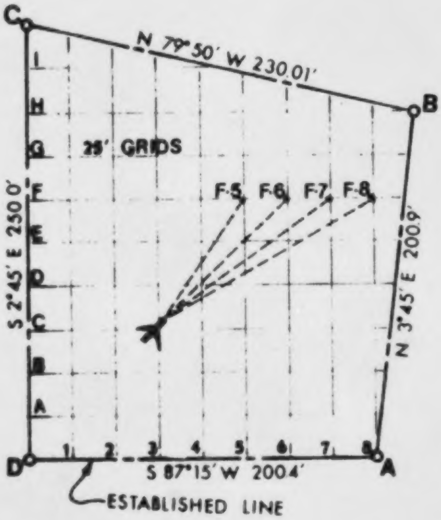


Fig. 5

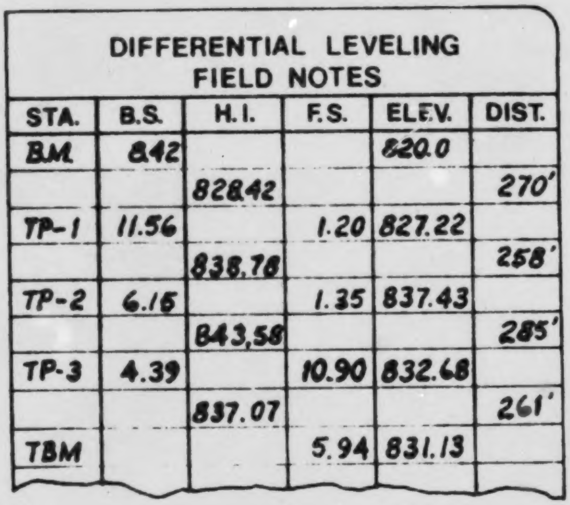
Differential Leveling - often called "a line of levels" is used when the distance between two points is too great, or the elevation between two points is too great to determine with one setting of the instrument.

Example: Establish a TBM from a distant BM

Procedure:

1. Study the job at hand! Become familiar with the topography, grade contours, variations in elevation.
2. Locate BM; establish desired TBM; select appropriate number of intermediate points between which:
   a. are approximately the same distance apart.
   b. can be read with a BS and a FS of the instrument set up between each two points.

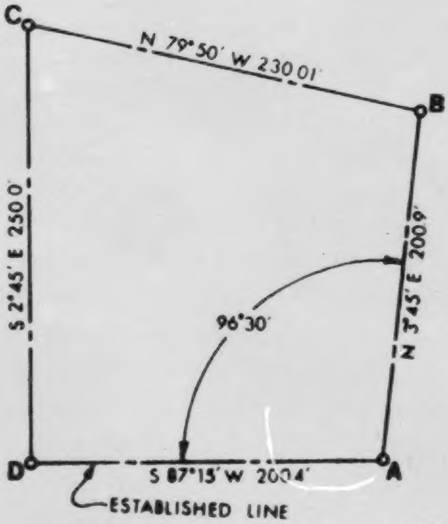
   Notes: Points do not have to be in a straight line. The distances between the instrument and each two points should be approximately the same. This may be accomplished by pacing off the distances.
3. Set up and level instrument equidistant between BM and TP-1. Take BS with rod held vertical at BM. Take FS with rod held vertical at TP-1. Record all readings.
4. Repeat step #3 between TP-1 and TP-2, 2 and 3 etc. until arriving at the TBM.
5. Total the BS readings; total the FS readings. The difference in totals equals the difference in BM and TBM elevations. If BS totals are greater than FS totals the TBM is higher than BM.
6. To check accuracy of work, run a second line of levels from the TBM back to the BM.



DIFFERENTIAL LEVELING FIELD NOTES

STA.	B.S.	H.I.	F.S.	ELEV.	DIST.
BM	8.42			820.0	
		828.42			270'
TP-1	11.56		1.20	827.22	
		838.78			258'
TP-2	6.16		1.35	837.43	
		843,58			285'
TP-3	4.39		10.90	832.68	
		837.07			261'
TBM			5.94	831.13	

Turning Horizontal Angles



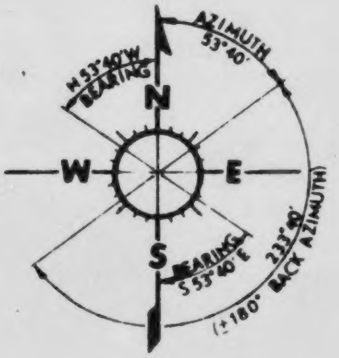
1. Set up instrument over the vertex of the angle (point A) at which the two sides meet:
   a. position instrument using the plumb bob.
   b. level the base and the telescope.
2. Sight the telescope along the first side (AD) of the angle:
   a. edge of rod held plumb at a point on line AD (may be point D).
   b. telescope vertical cross-hair aligned with edge of rod.
3. Tighten the clamp screw to hold the telescope in position and set the circular scale on the 0° indicator or 0° of vernier.

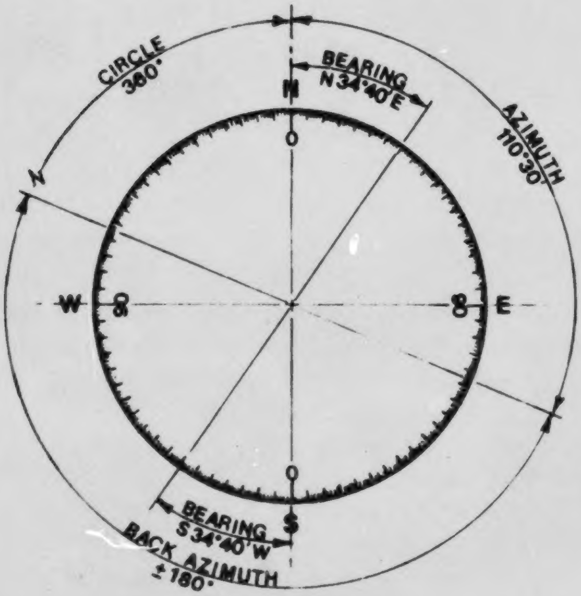
Note: Different model instruments vary in sequence of alignment and orientation. Steps 2 and 3 may be reversed on some models.

4. Set the telescope on the desired angle:
   a. swing telescope in direction to form angle.
   b. read circular scale to approach, but not pass desired angle.
   c. set final angle with tangent (fine adjustment) screw for accuracy.

Reading Angles:

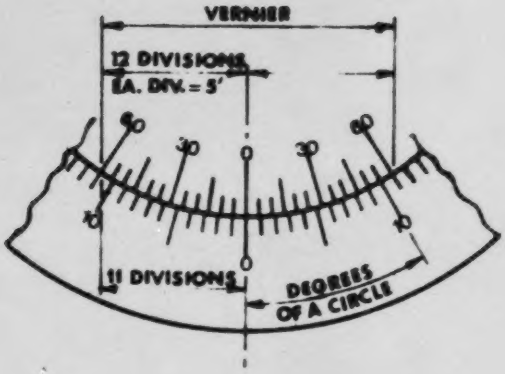
1. "Metes" in surveying means "directions." Compass directions given in terms of an angle generated from a point on a north-south line. These directions are given in degrees, minutes, and seconds. There are 360 degrees in a circle; 60 minutes in each degree; and 60 seconds in each minute. Directions are referred to as either azimuths or bearings. An azimuth is an angle generated from north as 0° in a clockwise direction. A bearing is an acute angle (less than 90°) generated from either north or south as 0°, in either an east or a west direction.

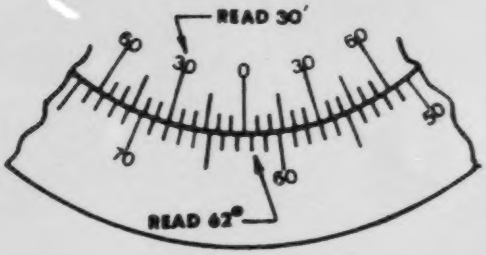




2. The circular scale is calibrated into 360 equal divisions. Each division represents one degree of a circle. The circular scale is also divided into four quadrants. Each quadrant measures 0° to 90° with the 0° marks (2) on opposite sides of the circle. When 0° are aligned with a north-south line this allows bearing angles to be easily generated and/or read. The circular scale 0° may be oriented to any line of known direction over a known point and angles generated or determined in the same manner although an angle being generated must first be calculated from known data (bearings and azimuths of lines forming the angle).

3. The vernier scale allows angles to be read accurately within minutes or seconds of a degree. The vernier is tangent to, and opposite of the graduations of the circular scale. A vernier, popular among building contractors, allows angles set or read accurately to one-twelfth of a degree-or five minutes.


VERNIER
12 DIVISIONS
EA. DIV. = 5'
60
30
0
30
60
10
10
0
11 DIVISIONS
DEGREES OF A CIRCLE


READ 30'
60
30
0
30
60
70
60
50
READ 62°

This vernier scale is composed of a 0° mark with twelve equal graduations on each side of 0. Each graduation of the vernier represents five minutes of a degree (5' x 12 = 60' or 1°). A twelve-unit arc on the vernier is equal to an eleven-degree arc of the circular scale.

To read the circular scale and vernier:

1. Always read in the direction of the increasing angle.
2. Read degrees when the vernier 0° mark lines up with a degree mark on the circular scale.
3. Read degrees and minutes when the vernier 0° mark passes a degree mark:
   a. locate a "five minute" calibration on the increasing side of the vernier which aligns with a degree mark on the circular scale.
   b. read minutes from the vernier 0 to the aligned marks on the vernier scale.

INSTRUCTOR'S PLAN
INFORMATIONAL LESSON

II-A-4(I)

SUBJECT:	**Building and Site Planning**
AIM:	The student will be able to discuss objectively the various facets of building and site planning as seen from both the architect's and the customer's point of view.
TEACHING AIDS:	Selected plot plans, topgraphical maps, abstracts and titles, blueprints and specifications, chalkboard
MATERIALS:	Home planning magazines, periodicals, chalk
REFERENCES:	REF. #2, Wagner, Willis H., Modern Carpentry, The Goodheart-Willcox Co., Inc., South Holland, IL 60473, Units Durbann, W. E., and Soundbert, E. W., Fundamentals of Carpentry, Vol. 2, American Technical Society, Chicago, IL 60637 REF. #1, F.H.A. Minimum Property Standards #300, US Department of Housing and Urban Development, Federal Housing Administration, Washington, D. C. 20410
PREREQUISITE EXPERIENCE OF THE LEARNER:	The student must have read the required references and acquainted self with blueprints and architectural symbols.

I. PREPARATION (OF THE LEARNER - MOTIVATION)

A home is usually the largest single investment the average person will ever make. But whether one is building a home with the intent to keep, or with the intent to sell for profit, this individual naturally wants the most value for the dollar invested.

During the building and site planning stage there are several factors which will enhance or adversely affect the beauty, attractiveness, and value of the finished product. Each must be considered separately; all must be considered as a whole. It is a "give and take" situation where, if you give more to one facet, you quite often give up from one or more other facets. Somewhere in between lies a happy medium.

The job of building site planning is usually left to the architect and the customer, but the building contractor and the student of building trades should possess a sound working knowledge of this phase of the trade, for quite often they are consulted on certain aspects within this area.

II. PRESENTATION (OF THE INFORMATION)

INSTRUCTIONAL TOPICS TEACHING POINTS	THINGS FOR STUDENT TO DO THINGS FOR INSTRUCTOR TO DO OR SAY
A. Three Major Considerations	1. Economics (cost) 2. Size and style (type)

3. Location and site
   Note: The three are very closely tied. It is difficult to discuss one without consideration of other two

B. Economics

1. Probably the most important factor
2. Cost has a direct bearing on every phase of the planning stage
3. Cost is the limiting factor
4. Individual wants most value for each dollar, i.e.,
   a. Sound design and construction
   b. Growing area; not a declining area
   c. One in which property value will appreciate
5. Individual seeks residential area compatible with his/her own economic life style, i.e.,
   a. Neighboring dwellings comparable in size and cost of home planned
   b. Neighboring dwellings in keeping with one's own idea of keeping house and grounds

C. Size and Style

1. Many types and styles blend well in a residential area
2. Home should fit the area and the site
3. Avoid large massive home on a small lot and vice-versa
   a. Makes home look pinched; crowded
   b. Usually does not fit-in with neighboring dwellings
4. Avoid a style completely out-of-place
   a. Ultra modern in an old neighborhood
   b. Sprawling ranch style in mountainous area
   c. Beach house in a city
5. Extreme designs should be avoided
   a. Usually more expensive to build
   b. Exotics more difficult to resell

D. Location and Site

Note: This is the most complex of the major considerations and will vary with each individual

1. General

1. Community
   a. Neighboring dwellings in keeping with size and type home planned

   - b. Stores convenient for daily shopping
   - c. Not too close to commercial/industrial area
   - d. Churches; school convenient
   - e. Bus lines convenient; both public and private
2. Utilities
   - a. What utilities are available ?
   - b. Locations and cost of connecting to existing utilities
   - c. Cost of providing your own utilities
3. Roads
   - a. Public or private
   - b. Condition and maintenance
   - c. Easements
   - d. Access to and from major thoroughfares
   - e. Possible future development into major thoroughfares
   - f. Elevation of road with respect to property
   - g. Road drainage
4. Abutting property
   - a. General "lay of the land"
   - b. Drainage important factor
     - (1) Not liable for natural drainage
     - (2) May be liable if topography altered to cause poor drainage onto neighboring property (either flow or backup)
   - c. Low spots that won't drain

2. Legal restrictions

1. National building codes
   - a. Specifications that have to be met in certain areas
   - b. Applied to protect owner
2. Local building code
   - a. Check with City Hall
   - b. Obtain copies
3. Local ordinances
   - a. Zoning - to separate types of construction
   - b. Civic restrictions
4. Easements-Authority to use and for a certain number of years by agreement or payment
   - a. Easements cannot be terminated unless

agreed to by the party owning the easement

- b. Easements may interfere with building or the putting in of utilities
- c. Blueprints show existing condition
  - (1) Underground easement-gas, water
  - (2) Overhead easement-telephone, electric

3. Topography

1. Contour of land
   - a. Hill, valley, rolling flat
   - b. Slope; how much? what direction?
   - c. Low spots and natural drainage
2. Soil composition and depth
   - a. Explain types of soil
   - b. Explain why density of soil is important
   - c. Explain compression of soils; before/after concrete is poured
   - d. Clay both compressible and impermeable
   - e. Clay makes quick drainage difficult
   - f. Sand non-compressible

   Note: Soil should be tested for compactibility
3. Rock and ledge
   - a. Check for outcroppings of rock and boulders
   - b. Test for suspected rock formations near surfaces; drive a sharpened steel bar depth of proposed excavation
   - c. Rock formation often expensive to excavate
   - d. Rock formation often associated with sub-surface water
4. Springs and presence of water
   - a. One of the most important items to look for
   - b. Usually a very expensive problem to solve or control
   - c. Look for low, continually damp areas
   - d. Frequently occurs in rock or shale formations
   - e. If suspected, dig a test hole depth of proposed excavation
5. Trees and shrubs
   - a. Enhance value of most home sites

  - b. Plan to cut down few as possible
  - c. Protect wanted trees during cutting, leveling, grading, excavating
- 6. Man-made obstacles
  - a. Underground utilities, pipelines
  - b. Old drainage pipe, culverts, septic systems
  - c. Old foundations, building footings, retainer walls
- 7. Plot plans and topographical maps
  - a. Symbols and representation
  - b. Contour lines and elevations
  - c. Dimensions and locations

III. APPLICATION (DRILL, ILLUSTRATIONS, ANALOGIES, ORAL QUESTIONS OR ASSIGNMENTS, MAKING INVESTIGATIONS OR EXPERIMENTS, NOTE TAKING, MAKING SKETCHES, PARTICIPATING IN DISCUSSION.)

1. Class to read and discuss (under guided supervision) the following:
   - a. Local building codes; ordinances

2. Class to examine parts of title and abstract

3. Class read and interpret preselected survey plot or plot plan (preferably plot class will build on)

4. Field trip:
   - a. Instructor to select potential building site
   - b. Obtain permission for class to visit sites
   - c. Class inspect each site and discuss conditions and potential of site
   - d. Class locate plot features as indicated on plot plan

5. Discuss home and site selection with class
   - a. Explain reasons for home and site selections
   - b. Students defend location of home on site in class critique

IV. VERIFICATION AND/OR EVALUATION (FINAL CHECK ON STUDENTS' COMPREHENSION OF MATERIALS PRESENTED.)

True-False

1.	Building and site planning is usually left up to the building contractor.	F
2.	Economics plays an important role in the building and site planning stage.	T
3.	A home is usually the largest investment made by the average person.	T
4.	Exotic designs of homes enhance resale value.	F

IV. VERIFICATION (CON'T.)

5. The neighborhood is not a determining factor for the style home. F

6. Roads do not adversely affect the choice of building sites. F

7. Rock formations are frequently associated with sub-surface water. T

8. Rock outcroppings are usually the most expensive problem to solve. F

9. Clay is both compressible and impermeable. T

10. Trees do not affect the property value of residential dwellings. F

V. SUMMARY (GIVE A BRIEF ACCOUNT OF EACH TOPIC REEMPHASIZING THE IMPORTANT POINTS. THIS SUMMARY MAY BE GIVEN AT ANY PLACE IN THE LESSON THE TEACHER FEELS WILL BE PROFITABLE TO THE STUDENTS.)

* The three major considerations in building and site planning are: (1) economics or costs; (2) size and style of home; (3) site or location.

* These three are very closely tied and it is difficult to discuss one without consideration of the other two.

* Economics (cost) is probably the most important as it is the limiting factor.

* A home is usually the largest investment the average person will ever make. Naturally, the individual wants the most value for each dollar.

* Individuals usually seek a residential area compatible with their economic life style; neighboring dewllings comparable in size and cost and in keeping with the individual's idea of house and grounds.

* Although styles may vary, the dwelling style and size should blend with the surroundings.

* Other considerations are: the community; roads; adjoining properties; utilities; legal restriction; soil (top and sub); presence of water, earth contour and natural drainage; trees and plants.

SUGGESTED READING FOR STUDENTS: REF. #3, Modern Carpentry, Unit 3

NEXT LESSON IS: II-A-5(I), "Building Site Preparation"

INSTRUCTOR'S PLAN
INFORMATIONAL LESSON

II-A-5(I)

SUBJECT: Building Site Preparation

AIM: The student will recognize the need for proper site preparation; be able to check existing site conditions against architect's plot plan, and follow sound procedures in preparing the site for building erection.

TEACHING AIDS: O/H project, Transparencies I.ED., chalkboard

MATERIALS: Chalk, blueprints

REFERENCES: Wagner, Willis H., Modern Carpentry, The Goodheart-Willcox Co., Inc., South Holland, IL. 60473
Durbann, W. E. and Soundbert, E. W., Fundamentals of Carpentry, Vol. 2, American Technical Society, Chicago, IL 60637

PREREQUISITE EXPERIENCE OF THE LEARNER: The student must have successfully completed previous informational lessons II-A-2(I), Blueprint Reading and II-A-3(I), Builder's Level and Transit Level

---

I. PREPARATION (OF THE LEARNER - MOTIVATION)

Upon becoming familiar with the planning and site selection phase of the building trades, it is now time to prepare the site for building construction.

Close attention to site preparation will not only preserve the aesthetic values envisioned by the architect, but will save time on part of the contractor after the actual job of building commences. Site preparation includes clearing unwanted growth and objects; protecting wanted growth and objects; grading, leveling and excavation including preserving and storing top soil for later use; and installing temporary services to include water, electricity, and delivery access for supply trucks.

II. PRESENTATION (OF THE INFORMATION)

INSTRUCTIONAL TOPICS TEACHING POINTS	THINGS FOR STUDENTS TO DO THINGS FOR INSTRUCTOR TO DO OR SAY
A. Locate and Mark Property Boundary	1. Identify existing land marks 2. Locate property corner 3. Establish property lines a. Set up transit level as per lesson II-A-1(S) at property corner b. Shoot property closure as per lesson II-A-2(S)

4. Mark property boundary
    a. Corners with metal posts
    b. Along property lines with surveyor's stakes

    Note: Do not take the word of a seller or neighbor although they may be sincere in their belief as to where the boundary is. The only sure way is to do it yourself or hire a licensed surveyor to do it

B. Check Building Site

1. Against architect's plot plans
    a. For objects noted on drawing
    b. For size, location of objects
    c. For lay-of-the-land (contour)
2. Note any discrepancies between drawings and actual site
    a. Objects that do not appear on drawings
    b. Objects not located as per drawing
3. Consult with architect on these differences
4. Obtain certified copy of soil tests

C. Plan Clearing and Grading

1. Determine rough location of building on site

    Note: This may be done quickly with steel measuring tapes as it is just rough location

    a. Locate one corner and one side of structure to be built
    b. Establish building outline
    c. Mark/stake building corners
2. Check building codes to verify distances from property lines; easements
3. Mark all trees, shrubs to be saved during clearing; grading
    a. Mark with ribbon streamers that are easily seen
    b. Stake around root systems not to be disturbed
4. Mark obstacles to be removed
    a. Unwanted trees; growth
    b. Old building footings, foundations, retainer walls, culverts
5. Locate and mark underground utilities, pipelines, storm sewers

    Note: Color code of markers may vary with contractor. One code is as follows:

    1. Blue marker - good; do not remove; save

   2. Red marker - remove; clear
   3. Yellow marker - caution
6. Set grade stakes as per lesson II-A-3(S) if necessary

D. Coordinate Clearing and Grading

1. Discuss job with equipment operator
   a. On site with plot plan in hand
   b. Point out markers
   c. Explain color code
   d. Make sure operator knows what to do
2. Set time schedule for:
   a. Heavy equipment operations
   b. Delivery of fill dirt, culverts, etc.
   c. Installation of temporary utilities
3. Check local ordinances on:
   a. "Stacking and burning" debris
   b. "Blasting" if necessary
   c. Installing "temp" poles, water line
4. Order material, equipment delivered at proper time
   a. Fill dirt, culverts, etc.
   b. Debris hauled off; dumped

E. Oversee

1. Removal and disposal of debris; unwanted growth
2. Scraping and piling of top soil not to interfere with construction; deliveries
3. Cut and fill to insure:
   a. Proper run-off; drainage
   b. Open ditches have sufficient capacity; taper
   c. Culverts correctly sized; installed
4. Installation of temporary utilities
5. All work in compliance with local ordinances, building codes, plans and specifications

---

III. APPLICATION (DRILL, ILLUSTRATIONS, ANALOGIES, ORAL QUESTIONS OR ASSIGNMENTS, MAKING INVESTIGATIONS OR EXPERIMENTS, NOTE TAKING, MAKING SKETCHES, PARTICIPATING IN DISCUSSION.)

* Class prepare checklist for building site inspection using blueprints and specifications

* Put checklist on chalkboard

* Class discuss performing checklist and field safety

III. APPLICATION (CON'T.)

- * Instructor form inspection teams and make assignments for field trip
- * Field Trip: Visit building site
  Teams perform assigned inspection/preparation tasks
  Note any discrepancies on blueprint (plot plan)
  Return to class
- * Class discuss field trip, prepare tentative schedule for site preparation

IV. VERIFICATION AND/OR EVALUATION (FINAL CHECK ON STUDENTS' COMPREHENSION OF MATERIALS PRESENTED.)

Performance test as per Manipulative Lesson II-A-3(S)

V. SUMMARY (GIVE A BRIEF ACCOUNT OF EACH TOPIC REEMPHASIZING THE IMPORTANT POINTS. THIS SUMMARY MAY BE GIVEN AT ANY PLACE IN THE LESSON THE TEACHER FEELS WILL BE PROFITABLE TO THE STUDENTS.)

- * Methodical preparation of the building site will preserve many aesthetic values envisioned by the architect as well as save time once construction commences.
- * Checking the actual site against the blueprints (plot plan) is a must. Any discrepancies should be noted and the architect consulted before work commences.
- * Color-coded flagging to note underground utilities, trees, and shrubs not to be disturbed should be discussed and pointed out to those doing the clearing and grading as should all items to be removed.
- * Check and comply with all city ordinances and local building codes during clearing and grading operations. Oversee all phases of same, including delivery and distribution of fill and the hauling off and/or burning of unwanted growth and debris.
- * Top soil should be scraped and piled for later use in final grading and where needed; grading stakes should be set and marked to aid in grading (cutting and filling).
- * Finish grades should insure proper drainage (run-off), and open ditches should have sufficient capacity, taper and culvert size to handle run-off.
- * Temporary utilities should be conveniently located for construction use and for later conversion to permanent utilities.

SUGGESTED READING FOR THE STUDENT:

Ref. #1, Modern Carpentry, pp. 87-90
Ref. #3, Fundamentals of Carpentry, pp. 43-47, pp. 65-68

The Next Lesson Is: II-A-6(I), "Layout Building Lines"

INSTRUCTOR'S PLAN
MANIPULATIVE LESSON

II-A-1(S)

TASK:	Establish and/or check property boundary lines
AIM:	The students will be able to lay out and mark property boundary lines for horizontal control of future construction.
TOOL AND EQUIPMENT:	Builder's transit-level, tripod, plumb bob, lining rod, 100' steel measuring tape, axe, machete, shovel, sledge hammer
MATERIALS:	Surveyor's stakes, laths, and hubs, 4d nails, flagging, lumber crayon or marker
TEACHING AIDS:	Project blueprints and plot plan
REFERENCES:	The World of Construction, pp. 174-179 Fundamentals of Carpentry, pp. 26-44
PREREQUISITE EXPERIENCE OF THE LEARNER:	The student must have successfully completed all lessons in Major Block I and lessons II-A-1(I), II-A-2(I), II-A-3(I) in Major Block II
CHECKING STANDARDS:	1. Safe work habits 2. Accuracy of computations, readings, measurements 3. Proper use and care of tools, equipment 4. Teamwork 5. Interest in successful completion of tasks

---

I. PREPARATION (OF THE LEARNER - MOTIVATION)

Before actual construction can begin, the boundaries of the site must be determined and/or positively confirmed as all construction on the site is generally located from these lines.

Unless a high degree of accuracy is maintained in establishing property lines, a chain of errors may occur, resulting in unforeseen costs and time delays which could eventually ruin a builder financially.

Control data and boundary dimensions are found on the plot plan sheet of the construction drawings. Site boundaries are established using a transit-level and steel measuring tapes and following the procedures in this lesson.

Since the successful completion of this task is very important to all future work on the project, every step must be checked and double checked carefully. The class will be evaluated as to how efficiently and accurately the task is completed.

II. PRESENTATION (OF THE SKILLS)

STEPS	KEY POINTS (THINGS TO REMEMBER TO DO OR SAY)
1. Locate Line Control References	1. On blue print plot plan 2. Property corner(s), one or more

- a. Dimensioned from existing landmarks
- b. Usually as coordinate dimensions

3. Property lines show "metes and bounds"
   Example: N 44° 48' E 120.8'

2. Discover Property Corner(s)
   1. On building site
      - a. Visually identify landmarks
      - b. As indicated on plot plans
   2. Verify locating dimensions
      - a. With steel measuring tapes
      - b. As per blueprint dimensions
   3. Find "steel rod" marker(s)
      - a. Two on same line if possible
      - b. With shovels, if necessary

   Note: Steel rod driven vertically into ground is surveyor's corner mark. Exercise care not to move or disturb

3. Establish P.O.B. (Point of Beginning)
   1. To shoot property boundary lines
   2. At one property corner location
   3. Make selection based on:
      - a. Plot plan data
      - b. Visual observation of property site

4. Set Up Tripod
   1. Unbuckle tie strap
   2. Ease leg friction
      - a. At tripod head
      - b. By turning wing nuts counterclockwise slightly

   Note: Some friction (stiff movement) is desirable

   3. Adjust leg lengths
      - a. To be same length
      - b. Loosen leg clamp thumb screw
      - c. Set lengths approximately 5'-0" long
      - d. Tighten thumb screws
   4. Stand tripod on feet
      - a. Legs spread 3'- 4' apart equally
      - b. Tripod head visually level
      - c. Set feet firmly

5. Mount Transit

   Note: Exercise care when handling not to bump or drop transit or damage threads

   A. Remove Transit
   1. From case
   2. With both hands
      - a. Hold by base of telescope
      - b. Lift straight out

B. Remove Protective Cap	1. From threads on tripod head 2. With counterclockwise rotation 3. Store in transit case
C. Position Transit	1. Bottom plate on tripod head 2. To engage threads on tripod head 3. Carefully not to damage threads
D. Secure Transit	1. Hold transit straight and steady with one hand 2. Rotate transit bottom plate clockwise with other hand 3. Engage threads handtight (snug) Caution: Do not force or cross-thread
E. Remove Protective Covers	1. From each end of telescope 2. Pull off gently 3. Store in transit case
F. Attach Sunshade	1. To lens end of telescope a. Squared end to telescope barrel b. Long side of bevel to top of barrel 2. Press over end of telescope gently
G. Affix Plumb Bob	1. To transit 2. With string attached to plumb bob 3. Suspend from plummet chain a. On bottom of transit b. Through ring opening in tripod head 4. Tie with slip knot
6. Position Transit	1. Over P.O.B. (steel rod marker) 2. Visually centered; visually level 3. About chest high a. With tripod legs 3'- 4' apart b. With two legs downhill on sloping ground 4. Adjust plumb bob to suspend approximately ¼" above P.O.B. 5. Move tripod legs slightly for plumb bob to suspend within ¼" of P.O.B. dead center 6. Set tripod feet firmly
7. Center Transit	1. Loosen two leveling screws a. Adjacent leveling screws b. On leveling head c. To free both pairs (opposite) leveling screws 2. Position hands around leveling head lower plate a. With heel and little finger of each hand on the plate

- b. With an arm of the leveling head spider between each thumb and forefinger

3. Shift transit slightly
    - a. By moving spider as required
    - b. So that plumb bob comes dead center over P.O.B.
4. Tighten leveling screws
    - a. Same two that were loosened
    - b. Finger tight (snug)

8. Level Transit

1. Check vertical arc vernier
    - a. Loosen vertical motion clamp screw
    - b. Set vertical arc vernier on 0°
    - c. Tighten vertical motion clamp screw
2. Loosen horizontal motion clamp screw
3. Rotate telescope to align over two opposing leveling screws
4. Tighten horizontal motion clamp screw
5. Face side of telescope with level tube
6. Turn leveling screws (2)
    - a. Aligned with telescope
    - b. In opposite directions
    - c. Simultaneously
    - d. With thumb and forefinger, each hand
7. Observe bubble in spirit level

Note: Bubble will follow direction of movement of left thumb

8. Bring telescope to level position (bubble between lines on level tube)
9. Loosen horizontal clamp screw
10. Rotate telescope 90° to align over opposite pair of leveling screws
11. Tighten horizontal clamp screw and repeat keypoints 5 through 8 to level

Note: Repeat keypoints 2 through 11 until spirit bubble remains level through 360° rotation

9. Orient Transit

1. With property boundary
2. When two corner markers on common boundary line have been located

A. Set Horizontal Vernier

1. To zero degrees
2. Loosen both horizontal motions (clamp screws)
3. Set plates to read approximately 0°
    - a. Hold upper plate in position

   - b. Turn lower plate by tangential pressure from underside
4. Tighten upper motion clamp screw (snug)
5. Set vernier 0° exactly opposite plate 0°
   - a. By means of upper tangent screw
   - b. Use positive clockwise motion only

Note: If zero runs beyond the point, back off and re-set. This prevents backlash (release of spring tension which could change the plate position)

B. Indicate Telescope

1. With lining rod
   - a. Set on second corner marker
   - b. Centered on marker
   - c. Held vertically
2. Rotate telescope
   - a. Lens end toward lining rod
   - b. With both hands on the plate edge or standards
   - c. Sight along top of telescope barrel
3. Trim limbs, branches
   - a. Along property boundary
   - b. For unobscured line of sight
   - c. With machete and/or hand axe

Note: Exercise safety in use of cutting tools. Avoid defacing desirable shrubs; trees

4. Adjust cross-hairs
   - a. While looking through telescope
   - b. Turn milled ring on eyepiece
   - c. Until cross-hairs become sharp and clear
5. Adjust focus
   - a. While looking through telescope
   - b. Turn telescope focus knob
   - c. Until lining rod is sharp and clear

C. Set Line of Collimation

1. With property boundary line
   - a. While sighting through telescope
   - b. Turn instrument
   - c. With both hands
   - d. On plate edge or standards (not on telescope)
2. Plumb lining rod with vertical cross-hair
   - a. Signal rodman to tilt lining rod as required
   - b. Until vertical cross-hair and edge of rod are parallel
3. Tighten lower motion clamp screw

4. Center cross-hair on rod point
    a. With lower tangent screw
    b. Finish with a positive motion

Check Point: The transit is centered over P.O.B.
The transit is level
The proper angle (0°) is on the plates
The line of sight is in a known direction
The transit is oriented!

10. Turn First Angle

1. Read compass bearing data
    a. Of intersecting boundary lines
    b. Forming included angle
    c. At P.O.B.
    d. On plot plan
2. Calculate included angle
    Example:

Known boundary line	N 89° 46' 20" W
Adjacent boundary line	N 2° 51' 05" W
Included ∡ @ P.O.B.	N 87° 86' 15" W

3. Loosen upper horizontal motion clamp screw
4. Turn upper plate in direction to form angle
5. Read vernier to approach, but not pass, desired angle
6. Tighten upper horizontal motion clamp screw
7. Set exact angle
    a. With horizontal tangent screw
    b. In same (positive) direction angle was turned
    c. Read degrees on circle; minutes on vernier

11. Establish 2nd Boundary Line and Corner

1. With angle set on transit
    a. Adjust focus and cross-hair as necessary
    b. For clear, sharp vision
2. Clear underbrush
    a. Along transit "line of sight"
    b. With axe; surveyor's machete
    c. For unimpeded vision; measurement
3. Measure boundary length
    a. As per plot plan data
    b. From transit point (P.O.B.)

c. Along transit line of sight
d. With long steel tape measure
e. Held straight, taut, visually level

A. Set Corner Hub

1. At taped distance
2. Position 2 x 4 stake
    a. Width facing transit
    b. Chisel point adjacent tape
    c. Thickness centered on measured distance
    d. Held vertically
3. Drive stake
    a. With sledge hammer
    b. Flush with ground

Note: Exercise care not to damage head of stake

B. Set Tack Point

1. Hold pencil point on stake
    a. Edge nearest transit
    b. Approximately centered
2. Plumb pencil with transit
    a. Pencil point centered with vertical cross-hair
    b. Pencil body parallel with vertical cross-hair

Note: If distance prohibits use of pencil, lining rod may be employed

    c. Mark point on edge of stake
3. Repeat keypoints 1 & 2 above on far edge of stake
4. Scribe line
    a. On top of stake
    b. Between points marked
5. Mark measured distance
    a. With tape next to scribed line
    b. Position pencil at point of measurement
    c. Scribe arc to intersect line
6. Drive 4d nail
    a. Almost flush (about 1/8") to top of stake
    b. At intersection of scribed arc and line

Check point: Check transit level
Check angle reading to agree with plot plan data
Check tack point aligned with vertical cross-hair (use lining rod)
Check boundary side (P.O.B.-2nd corner) to agree with plot plan data

II. PRESENTATION (CON'T)

12. Move Instrument To New Corner	1. Remove plumb bob 2. Close tripod legs a. While holding in vertical position b. Shift weight slightly as required to close c. Fasten leg strap about legs 3. Position tripod on shoulder a. With feet forward, transit behind head b. Balanced on shoulder for easy carrying 4. Carry transit-tripod assembly a. With arms crossed over tripod legs b. Carefully not to bump or drop transit
13. Set Up, Center, and Level Transit	1. Over 2nd corner 2. As per steps 6, 7, 8, this lesson
14. Orient Transit	1. Similar as in step 9 2. Set line of collimation with boundary just established
15. Turn Angle and Establish Next Boundary, Corner	1. Similar as in steps 10 & 11 2. Continue repeating steps 6-12 until all corners, all boundaries are established Note: The completion of the job should present a closure at the P.O.B.
16. Mark and Flag Property Corners	1. With $\frac{1}{2}$ x 2" x 36" surveyor's lath a. Set vertically b. About 6" into ground c. Adjacent to hub 2. Flag with bright yellow streamers 3. Mark with keel or lumber crayon to identify Example: NE Cor. site (northeast corner of site)

III. APPLICATION (PRACTICE BY LEARNER UNDER CLOSE SUPERVISION)

1. Students practice setting up transit
2. Students practice centering, leveling transit over given point
3. Students practice orienting transit, turning angles, reading angles
4. Students practice shooting, measuring lines
5. Students make bearing, azimuth computations

IV. VERIFICATION AND/OR EVALUATION (CHECK ON STUDENT'S ABILITY)

Students perform job,tasks to a degree of accuracy suitable for construction purposes.

V. SUMMARY (TELL THE STEPS ON PROCEDURE AS TO WHAT, HOW, AND WHY. REVIEW CHECKING STANDARDS. THIS SUMMARY MAY BE GIVEN AT ANY PLACE IN THE LESSON THE TEACHER FEELS WILL BE PROFITABLE TO THE STUDENTS.)

- Locate line control data on blueprint plot plan
- Discover property corner(s) on building site. Generally steel rod markers in ground
  a. Visually identify landmarks
  b. Verify dimensions with tape measure, compass
  c. Find steel rod marker
- Establish P.O.B. - "point of beginning"
- Set up transit over P.O.B.
- Center, level transit over P.O.B.
- Orient transit
  a. Plates on 0°
  b. Line of collimation on known boundary line
- Turn angle and measure boundary length
- Set hub and measure boundary length
- Move transit to new tack point
- Set up transit and continue to shoot boundary closure
- Mark and flag boundary corners

SUGGESTED READING FOR THE STUDENT:

Modern Carpentry, Unit 6

The Next Lesson Is: II-A-2(S), "Establish Preliminary Building Lines And Mark For Clearing"

JOB SHEET
IN
BUILDING SITE PREPARATION

NAME OF JOB:	Establish And/Or Check Property Boundary Lines
DRAWINGS:	Blueprint plot plan
MATERIALS:	Surveyor's laths, 8d finishing nails, 2" x 2" x 12" lg. stakes, nylon cord
TOOLS AND EQUIPMENT:	Builder's level, machete, engineer's hammer (3lb.), tripod, axe, 100' steel measuring tape (2), plumb bob, shovel, lining rod, hand sickle (grass)
GENERAL INSTRUCTIONS:	Study blueprint plot plan. Familiarize yourself with landmarks used as base points for locating property lines; overall size and shape of the property. Review Information Sheet II-A-3(IS), Builder's Level, Transit Level, and Equipment.
PROCEDURE AND/OR TASK:	II-A-1(TS) Establish P. O. B. (Point of Beginning) II-A-1a(TS) Set Up And Level Instrument
CHECK POINTS:	Instrument centered over P. O. B. Instrument is level Horizontal vernier set on 0° Telescope line of sight in a known direction II-A-1b(TS) Shoot Property Closure

TASK SHEET

II-A-1(TS)

TASK:	Establish P. O. B. (Point of Beginning)
JOB:	Establish And/Or Check Property Boundaries
TRADE:	Building Trades
TOOLS AND MATERIALS:	100' steel measuring tape (2), hand sickle, machete, shovel, axe

TASK BREAKDOWN:

STEPS		KEY POINTS
1. Locate Line Control References	1.	On building site
	2.	Visually identify landmarks
	3.	As indicated on blueprint plot plan
2. Discover Property Corner(s)	1.	Two on same line if possible
	2.	Measure from line control references
	3.	Dimensions as per plot plan
	4.	Use intersecting tape measures
	5.	Find "steel rod" marker
	6.	At location of intersecting tape measurements
	7.	Use shovel if necessary
	Note:	Steel rod driven vertically into ground is surveyor's corner mark. Do not move or disturb
3. Establish P. O. B. (Point of Beginning)	1.	To shoot property boundary lines
	2.	At one property corner location
	3.	Make selection based on: a. plot plan data b. visual observations

TASK SHEET II-A-1a(TS)

TASK: Set Up And Level Instrument

JOB: Establish And/Or Check Property Boundaries

TRADE: Building Trades

TOOLS AND MATERIALS: Builder's level, tripod, plumb bob

TASK BREAKDOWN:

STEPS	KEY POINTS
1. Set Up Tripod	1. Unbuckle leg strap and ease leg friction at tripod head 2. Check and adjust leg lengths evenly to approximately 5' long 3. Spread legs evenly 3' - 4' apart and position tripod over desired location Note: On sloping ground, position two legs downhill 4. Set legs firmly in ground with head visually level 5. Tighten wing nuts at tripod level 6. Remove protective cap from head and store in case
2. Mount Instrument	1. Remove instrument from case carefully using both hands Note: Do not life or hold instrument by the telescope. Do not bump or drop instrument 2. Position instrument base on tripod head to engage threads 3. Hold instrument steady with one hand; engage threads handtight(snug) with other hand Note: Do not force or cross threads 4. Remove lens cover and store in case 5. Install sunshade on scope
3. Center Instrument	1. Suspend plumb bob on a cord from the plummet at the bottom of the instrument Note: Point of plumb bob just above the level of the marker in the ground 2. Adjust (move) legs slightly to bring plumb bob within ¼" of center of marker;

STEPS	KEY POINTS
	maintain visual level of tripod head
	3. Position plumb bob directly over center by loosening two adjacent leveling screws and shifting the instrument on its base plate to center plumb bob
	4. Tighten leveling screws
4. Level Instrument	1. Loosen horizontal motion clamp screw and align telescope over two opposing leveling screws; tighten clamp screw
	2. Turn leveling screws, two aligned on, in same direction simultaneously with the thumb and forefinger of each hand
	Note: Observe buble in spirit level. The bubble will follow the direction of movement of the left thumb
	3. Center bubble between lines of the level tube. Tighten level screws gently
	4. Loosen horizontal motion clamp screw and rotate telescope 90° to align over opposite two leveling screws. Tighten clamp screw
	5. Repeat key points #2 and #3 above
5. Check Instrument Level	1. Loosen horizontal motion clamp screw
	2. Rotate telescope slowly 360°
	3. Observe bubble in level tube – bubble should not move out of center position (from between the lines on the level tube)
	Note: If instrument is not level, repeat step #4 until it is

TASK SHEET

II-A-1b(TS)

TASK:	Shoot Property Closure
JOB:	Establish And/Or Check Property Boundaries
TRADE:	Building Trades
TOOLS AND MATERIALS:	Builder's level, machete, surveyor's lath, tripod, axe, plumb bob 2" x 2" x 12" lg. stakes, engineer's hammer, 8d finish nails, nylon cord, lining rod

TASK BREAKDOWN:

STEPS	KEY POINTS
1. Set Up And Level Instrument	1. Over P. O. B. 2. As per task sheet II-A-1a(TS), preceding
2. Set Horizontal Vernier on 0°	1. Loosen both horizontal motion clamp screws 2. Hold upper plate in position 3. Turn lower plate using tangential pressure from under side 4. Tighten upper motion clamp screw
3. Align Telescope	1. When two corner markers on a common boundary line have been located 2. Indicate telescope with lining rod set vertically on second corner marker 3. Adjust focus and cross-hair for sharp image 4. Plumb lining rod with vertical cross-hair using hand signals to communicate with rodman 5. Tighten lower motion clamp screw 6. Center cross-hair on rod point using horizontal tangent screw
CHECK POINTS:	Check: Instrument centered over P. O. B. Instrument is level The proper angle (0°) is on the plates The line of sight is in a known direction The instrument is oriented
4. Turn First Angle	1. Read compass bearing date — boundary lines forming included angle 2. Calculate included angle in degrees 3. Loosen horizontal motion clamp screw

STEPS	KEY POINTS
	4. Turn upper plate (telescope) in direction to form angle 5. Read horizontal vernier to approach, but not pass, desired angle 6. Tighten horizontal motion clamp screw 7. Set exact angle with horizontal tangent screw
5. Shoot 1st Property Line	1. Use vertical cross-hair for alignment 2. Stretch nylon cord to mark boundary line 3. Measure "metes" accurately using steel measuring tapes 4. Locate property boundary marker (surveyor's steel rod) or . . . 5. Mark property corner with 2" x 2" x 12" lg. stake driven flush to ground with 8d finish nail in top marking exact spot
6. Shoot 2nd Property Line	1. Move level instrument to property corner just located and/or marked 2. Set up and level instrument as per step #1 3. Set horizontal vernier on 0° and align telescope with property line just established as in steps #2 and #3 4. Turn new angle similar as in step #4 5. Shoot new property line as in step #5 Note: Continue to move to new point, set up, turn calculated angles and shoot property lines until a closure is achieved

INSTRUCTOR'S PLAN
INFORMATIONAL LESSON

SUBJECT:	Layout Building Lines
AIM:	The student will be able to layout building lines using dimensions taken from the plot plans by using a transit level and/or the 6-8-10 method of triangulation.
TEACHING AIDS:	O/H projector, Transparencies BT-I-T, Figs 1 through 4, BT-II-T, Fig 1; Chalkboard
MATERIALS:	Chalk
REFERENCES:	Wagner, Willis H., Modern Carpentry, The Goodheart-Willcox Co., Inc., South Holland, IL 60473, pp. 88-93 Durbann, W. E. and Soundbert, E. W., Fundamentals of Carpentry, Vol. 2, American Technical Society, Chicago, IL. 60637, pp. 64-74
PREREQUISITE EXPERIENCE OF THE LEARNER:	The student must be proficient in the use and care of measuring instruments; be able to read and interpret blueprints, and perform mathematical calculations in feet and inches.

I. PREPARATION (OF THE LEARNER - MOTIVATION)

The layout of building lines is critical in that all construction which follows must conform to these lines.

Extreme accuracy during layout, followed by a check of the layout is a must for the ease of construction which follows. A poor job of laying out building lines will compound the troubles of construction and multiply the costs.

Laying out building lines is not a difficult job, but it is an important job. Knowing what to do, when and how to do it, is the key of success to any job.

II. PRESENTATION (OF THE INFORMATION)

INSTRUCTIONAL TOPICS TEACHING POINTS	THINGS FOR STUDENT TO DO THINGS FOR INSTRUCTOR TO DO OR SAY
A. Determine Base Line and Base Point	Note: Base line is usually the building front and parallel with the property front boundary but any building line may be used
	1. Study blueprints (plot plan)
	a. Dimensions given from property boundaries
	b. To at least two adjacent sides of building
Show Transparencies: BT-I-T, Figs. 1 and 2	c. Sides intersect to form base corner

	2. Decide most logical base line and base point (starting point for building layout)
B. Layout Base Line 1. Measure	Note: Illustrate on chalkboard 1. From property boundary 2. Two places as far apart as possible 3. Dimension indicated on plot plan
2. Mark Points of Measurements	1. With surveyor's stakes 2. Width of stakes parallel to property boundary 3. Set firmly into ground 4. In vertical position
3. Stretch Nylon String	1. In line with stakes 2. Approximately 4-6 inches above ground Note: String represents base line. Double check dimensions
C. Locate Base Point 1. Measure	1. From adjacent property line 2. Along extended base line 3. Dimension indicated on plot plan
2. Set Stake	1. (2" x 2" x 12" lg.) firmly into ground 2. In vertical position 3. At point measured 4. Allow approximately 4" above ground
3. Mark Exact Point	1. In top of stake 2. With 8d finish nail 3. Set vertical with 1/2" exposed Note: Nail represents base point. Double check dimensions
D. Layout Building Corners Using 6-8-10 Method	Note: This method may be used only when building corners are right angles (90°)
1. Pythagorean's Theory	1. States, "In any right triangle (a triangle with one 90° included angle), the sum of the squares of the two short legs is equal to the long leg 2. A triangle with sides 3,4,5, or triangles with multiples of these numbers, are such triangles 3. Hence; 6-8-10 method of laying out right angles is derived from this geometric principle
2. Layout Base Line and Base Point 2	1. As per steps B and C, this lesson 2. Label base point, point "A"

3. Establish Point "B"	1. Measure 8'-0" back along building line from point "A" 2. Set nail in top of stake exactly 8'-0" on building line as in step C this lesson
4. Establish Point "C"	1. Place 10'-0" measuring tape with 0" at point "B" 2. Place 6'-0" measuring tape with 0" at point "A" 3. Swing 6'-0" and 10'-0" arcs in direction of desired angle Note: Illustrate on chalkboard 4. Drive stake in ground at point of intersecting arcs 5. Set nail in top of stake at exact point of intersecting arcs
5. Stretch New Lines	1. From point "A" 2. Through point "C" 3. Length of new side according to blueprint Note: The included angle between lines is 90°. Continue around building outline using 6-8-10 method to layout square corners
E. Layout Building Corners Using Perpendicular Bisectors	Note: This is an alternate method for laying out building corners that are 90°
1. Layout Base Line and Base Point	1. As per steps B and C, this lesson 2. Label base point, point "A"
2. Establish Points B and B_1	1. On base line 2. 6'-0" each side of point "A" 3. Mark exact spot as in step C-3, this lesson
3. Establish Points C and C_1	1. Place 10'-0" measuring tapes with 0" at points B and B_1 2. Swing arcs to one side of base line 3. Mark point of intersection a. Of 10'-0" arcs b. With nail set in top of stake c. As per steps C-2 and 3, this lesson 4. Swing arcs to opposite side of base line 5. Mark point of intersection
4. Stretch New Line	1. Through points C and C_1 2. Extend in direction of new side Note: The included angle between lines is 90°. Continue around building outline using the perpendicular bisector to layout square corners

F. Layout Building Corners Using Builder's Level	Note: This method is used when building corners may/may not be right angles (90°)
1. Layout Base Line and Base Point	1. As per steps B and C, this lesson 2. Lable base point, point "A"
2. Set Up Instrument	1. Over base point "A" 2. Attack plumb bob 3. Adjust tripod a. Correct height b. Approximately level c. Plumb bob directly over nail in base point 4. Level instrument
3. Align Instrument	1. With base line 2. Using surveyor's rod a. Align rod edge with base line b. Align vertical cross-hair with rod edge 3. Adjust vernier scale to 0° setting
4. Shoot New Line	1. Rotate instrument a. Desired direction of new building line b. Degrees (angle) according to blueprint 2. Sight new line a. Through level tube b. Using vertical cross-hair c. Align edge of surveyor's rod 3. Set new line a. Stretch nylon string b. From nail in base post c. In line with edge of rod 4. Measure length of new side as per blueprint
G. Check Building Lines For Squareness	Note: Diagonals of a square or rectangle are always equal in length 1. Illustrate on chalkboard a. Opposite sides of any square/rectangle are equal b. By definition, all included angles are 90° c. By observation, diagonals form right triangles whose base and height are the same d. Hence, diagonals are the same
Show Transparency: BT-I-T, Figs. 4a and 4b	2. Measure diagonally across opposite corners of square building section 3. Compare measurements

   a. When measurements are the same building is square

H. Set Batterboards

Note: Batterboards are used to mark building lines during any excavation and/or setting of foundation forms

1. Select Material

1. Three 2 x 4 stakes each corner
   a. Long enough when driven firmly into ground they will extend 6" above foundation line
   b. Sharpen ends into wedge points
2. Two 1 x 6 ledger boards each corner
   a. Approximately 6' long
   b. Straight, good quality

Note: Additional stakes and ledgers are required if plans call for building offsets

2. Drive Stakes

Show Transparency:
BT-I-T, Fig. 4a

1. Firmly into ground
2. In a vertical position
3. Approximately 4'-0" outside building lines
4. Aligned parallel to building lines
5. Forming 90° angle outside building corner

Note: Stakes to extend above ground approximately 6" higher than "top of foundation" line

3. Nail Ledger Boards

1. To stakes
2. On outside
3. Level with top of foundation
   a. Mark top of foundation on one (1) corner stake
   b. Use builder's level to position ledgers level with mark
   c. Use line and line level to mark other corners

4. Stretch Lines

1. From top-to-top of opposing batterboards
2. Directly over points (corners) of building line
   a. Use plumb bob for accuracy
   b. Use nylon line; stretch taut
3. Mark tops of ledgers at lines
4. Cut shallow saw kerf at lines
5. Set nail below kerfs in outside of ledgers
6. Fasten lines to nails

Note: Where offsets occur install additional batterboards and stretch extra lines

III. APPLICATION (DRILL, ILLUSTRATIONS, ANALOGIES, ORAL QUESTIONS OR ASSIGNMENTS, MAKING INVESTIGATIONS OR EXPERIMENTS, NOTE TAKING, MAKING SKETCHES, PARTICIPATING IN DISCUSSION.)

* Divide class into teams for competition

* Furnish teams with materials, equipment, and drawing

* Teams layout building lines and set batterboards as per drawing

IV. VERIFICATION AND/OR EVALUATION (FINAL CHECK ON STUDENTS' COMPREHENSION OF MATERIALS PRESENTED.)

Multiple Choice

1. The first step in laying out building lines is to: A
   - a. study the blueprints
   - b. establish property boundaries
   - c. layout base line
   - d. locate base corner

2. In building layout, the base line is usually: C
   - a. the front property line
   - b. adjacent to front property line
   - c. parallel with front property line
   - d. independent of property lines

3. Exact corners of a building layout are marked with: D
   - a. metal stakes
   - b. 2' x 2" wood stakes
   - c. surveyor's stake
   - d. finish nail set in top of stake

4. A right triangle has: B
   - a. no 90° included angles
   - b. one 90° included angle
   - c. two 90° included angles
   - d. two equal sides

5. The long leg of a right triangle whose short legs are 27" and 36" is: A
   - a. 45"
   - b. 48"
   - c. 56"
   - d. 60"

IV. VERIFICATION (CON'T.)

6. A quick check for accuracy of building layout is: B

   a. retrace measurements
   b. measure diagonals
   c. calculate angles mathematically
   d. use transit level

7. Other than the 6-8-10 method, another method of laying out square building corners is: D

   a. Pythagorean's Theory
   b. measure diagonals
   c. trial and error
   d. perpendicular bisector

8. The horizontal boards to which building lines are stretched are called: C

   a. batten boards
   b. form boards
   c. ledger boards
   d. nailer boards

9. Batter boards are used to: B

   a. mark grade lines during excavation
   b. mark building lines during excavation
   c. mark foundation heights for form construction
   d. mark building lines for wall framing

10. Ledger boards are best marked with: C

    a. chalk line
    b. pencil line
    c. shallow saw kerf
    d. sharp crayon

V. SUMMARY (GIVE A BRIEF ACCOUNT OF EACH TOPIC REEMPHASIZING THE IMPORTANT POINTS. THIS SUMMARY MAY BE GIVEN AT ANY PLACE IN THE LESSON THE TEACHER FEELS WILL BE PROFITABLE TO THE STUDENT.)

* The layout of building lines is not a difficult job, but is an important job in that all construction which follows must conform to these lines.

* Accuracy and squareness are the keywords, for a poor job of laying out building lines will compound the troubles of construction and multiply its costs.

* Study the blueprints (plot plan) and determine which building line and corner are

best to use as a starting point for the building layout. Usually one side of the building (front, for example) is parallel to a property boundary line (the property front).

- Layout base line (also one building line) and locate base point (also one building corner) according to dimensions on plot plan. Layout square building corners using the 6-8-10 triangle or the perpendicular bisector method.
- Measure accurately and mark all building corners by driving a 2 x 2 inch square stake, in vertical position, firmly into the ground and setting a finish nail on the exact spot in the top of the stake.
- After layout is complete, check building line measurements; check diagonals of building line rectangles to be equal; and check distances to property line for proper location.
- If building lines are correct, set batterboards and stretch nylon lines directly over building lines using plumb bobs for exact location.
- Excavation and foundation forms are now ready to be set.

SUGGESTED READING FOR STUDENTS:

Ref. # 10, Construction Materials And Processes, pp. 13-26

The Next Lesson Is: II-A-7(I "Soil Preparation And Special Excavation"

INSTRUCTOR'S PLAN
MANIPULATIVE LESSON

TASK:	Establish preliminary building lines and mark for clearing
AIM:	The students will be able to lay out and mark preliminary building lines, and mark undesirable vegetation and obstacles to be cleared from site.
TOOLS AND EQUIPMENT:	100' steel measuring tape, (2) 12' steel measuring tapes, 3 lb. engineer's hammer or light sledge hammer
MATERIALS:	Nylon cord, surveyor's laths, (1) roll each, red, yellow, blue plastic ribbon flagging, keel or lumber crayon marker, red paint, and paint brush
TEACHING AIDS:	Project blueprints and plot plan
REFERENCES:	Modern Carpentry, pp. 88-89 Fundamentals of Carpentry, pp. 43-49
PREREQUISITE EXPERIENCE OF THE LEARNER:	The student must successfully complete Major Block I and lessons II-A-2(I), II-A-4(I), II-A-5(I), II-A-6(I)
CHECKING STANDARDS:	1. Safe work habits 2. Accuracy of measurements, layout 3. Proper use and care of tools, equipment 4. Proper, accurate flagging for clearing operation 5. Interest in successful completion of tasks

---

I. PREPARATION (OF THE LEARNER - MOTIVATION)

Before site clearing begins, the builder should meet with the contractor or architect on the site and discuss the clearing operation. It should be agreed upon at this time exactly what stays and what goes; that is, exactly which trees and shrubs should be preserved, and which ones removed, and the same for other existing objects.

Since line controls (property boundaries) have already been established (previous lesson), the next step is to locate the building outline on the property as all trees, shrubs, etc., within the actual building area must be cleared. Once the building corners are located, all undesirable vegetation and structures must be identified and marked for clearing.

After the site is prepared for clearing, actual clearing is generally performed by a sub-contractor under the observation and supervision of the class. Individual students will be given individual supervisor assignments.

II. PRESENTATION (OF THE SKILLS)

STEPS	KEY POINTS (THINGS TO REMEMBER TO DO OR SAY)
	Note: Most buildings and dwellings parallel property frontage. This fact is assumed for the following procedure. Verify fact before each job with plot plan data
1. Mark Property Front Boundary	1. With nylon string 2. Stretched straight and taut 3. From corner to corner 4. Established in previous lesson II-A-1(S) 5. Tie to nail in corner hubs
2. Measure Building Front Offsets	1. With steel measuring tape 2. From front corner location 3. Along front property line 4. As per plot plan dimensions a. Building front offset b. Building front length
3. Mark Front Offsets	1. At points measured 2. With surveyor's lath a. Place edge to string b. Hold vertically c. Drive into ground approximately 6" deep or until positioned firm
4. Stretch Depth Offset Lines	1. Perpendicular (square) to front property line 2. At front offsets just marked 3. Extending into the property depth 4. Use 6-8-10 method or perpendicular bisector method to lay out lines
A. 6-8-10 Method	1. Measure 6'-0" a. From building front offset b. Along front property line c. Mark point measured on line 2. Position 10' tape at point marked 3. Position 8' tape at front offset 4. Swing arcs into property until 10' tape and 8' tape intersect 5. Stretch a line from front offset through intersection point of tapes Note: This line is perpendicular (square) with front property line

B. Perpendicular Bisector Method

1. Measure 6'-0"
   - a. Each side of building front offset
   - b. Along front property line
   - c. Mark points measured on line
2. Position 12' tapes at points marked
3. Swing arcs into property until 12'-0" on tapes intersect
4. Stretch line from front offset through intersection point of tapes

Note: This line is perpendicular (square) with front property line

5. Measure Depth Offsets

1. With steel measuring tape
2. From front offsets (2)
3. Along depth offset lines
4. Dimensions as per plot plan
   - a. Building depth offset
   - b. Building depth

6. Mark Depth Offsets

1. At points measured, both lines
2. With surveyor's laths, set between the lines
3. Set laths similar as per step #3 above
4. Mark laths
   - a. With bright blue-ribbon streamers
   - b. With keel; NW, SW, SE, or NE Bldg. Cor.

Check Point:

Note: These points represent the building corners. Double check with instructor:

1. Building outline dimensions (overall)
2. Building front offset dimensions
3. Building depth offset dimensions
4. Building corners square (diagonal corners equal distance)

7. Mark Undesirable Vegetation

1. For removal
2. With bright red ribbon streamers
   - a. Tie to bush, shrub, or tree to be removed
   - b. Tie approximately eye level, or plainly visible

Note: Undesirable vegetation includes:

- a. All vegetation within building lines
- b. Dead, diseased, scrub trees
- c. Scraggly, thorny poisonous bushes, plants

Check Point:

Double check with instructor:

- a. Trees not indicated on plot plan
- b. Questionable shrubs

8. Mark Unwanted Structures	1. For removal 2. With bright red paint a. 6" spot or band plainly visible b. Approximately eye level where possible Note: Unwanted structures may include: a. Old buildings, footings, foundations b. Culverts, retainer walls, rock outcroppings
9. Mark Caution Areas	1. As per plot plan data and dimensions a. Underground water, sewer lines b. Underground utilities, any other 2. With surveyor's laths a. Set vertically in ground b. At approximately 15' intervals c. Over underground lines 3. Flag with bright yellow streamers a. Denotes caution b. Tie at top of laths 4. Mark laths to identify Example: U'GR. UTIL. -12" DP. (underground utility -12" deep)
10. Mark Desired Structures, Vegetation (Optional)	1. Of special circumstance for special notice Examples: a. Desired tree in cluster with undesired trees b. Desired fence grown over with undesired shrubs c. Low arching bough or tree 2. With bright blue ribbon streamers 3. To be clearly visible
11. Assist Sub-Contractor In Site Clearing	1. Discuss site clearing with machine operators 2. Explain flagging color code 3. Observe clearing operation 4. Provide control information as required a. For removal of undesirable vegetation, structures b. For protection of desirable vegetation, structures Note: Exercise extreme alertness and caution when in area where heavy equipment is operating

III. APPLICATION (PRACTICE BY LEARNER UNDER CLOSE SUPERVISION)

1. Students practice laying off building offsets on a line
2. Students practice making intersecting measurements with two tapes
3. Students practice setting lines perpendicular (square) to a given line at a given point
4. Students become familiar with project plot plan drawing
5. Class tour site -- discuss clearing/grading with instructor

IV. VERIFICATION AND/OR EVALUATION (CHECK ON STUDENT'S ABILITY)

1. Students set laths to mark proposed building corners within acceptable limits
2. Students mark building site for clearing operation
3. Observe and advise clearing operations safely and successfully

V. SUMMARY (TELL THE STEPS ON PROCEDURE AS TO WHAT, HOW, AND WHY. REVIEW CHECKING STANDARDS. THIS SUMMARY MAY BE GIVEN AT ANY PLACE IN THE LESSON THE TEACHER FEELS WILL BE PROFITABLE TO THE STUDENTS.)

* Mark property front boundary with nylon line stretched from corner to corner

* Measure building front offsets along front property line and mark with surveyor's laths set vertically, with edge to measured dimension

* Stretch depth offset lines, at points marked, perpendicular (square) with property front and extending into property

* Measure depth offsets (2) on each perpendicular line and mark with surveyor's laths set vertically with edge to measured dimensions and between lines

* Mark laths with bright blue ribbon streamers tied to top of lath; with keel or lumber crayon write on lath "NE, NW, SE, or SW Bldg Cor."

* Mark site for clearing
  a. Unwanted vegetation, obstacles - bright red ribbon streamers or paint plainly visible
  b. Caution areas (underground utilities)- surveyor's laths with bright yellow ribbon streamers tied at top
  c. Desired vegetation, structures - bright blue ribbon streamers plainly visible

* Discuss clearing with machine operators; explain flagging color code; observe clearing and provide control information as required

* Exercise extreme alertness and caution during clearing operation where heavy equipment is operating

SUGGESTED READING FOR THE STUDENT:

The Next Lesson Is: II-A-3(S), "Establish TBM (Temporary Bench Mark)"

II-A-2(J)

JOB SHEET
IN
BUILDING SITE PREPARATION

NAME OF JOB: Establish Preliminary Building Lines; Mark For Clearing

DRAWINGS: Blueprint plot plan; floor plan

MATERIALS: Nylon cord, 8d finish nails, (1) roll ea. red, yellow, and blue streamer, 2" x 2" x 12" lg. stakes, surveyor's laths

TOOLS AND EQUIPMENT: 100' steel measuring tape, 3 lb. engineer's hammer

GENERAL INFORMATION: Generally a main building line parallels one property line. In residential construction this is usually true with the building front and the front property line. This is the circumstance for the task listing in this job sheet. However, the principles employed may serve similarly in most situations with some initiative applied to the location of the building offsets.

The extent of marking vegetation and objects for clearing depends largely on the existing topography — what is desirable and what is undesirable. Some sites need little clearing while others may require extensive clearing. The extent of "marking" is usually determined by the conditions of each individual site.

PROCEDURE AND/OR TASKS:

1. Mark property front boundary — with nylon cord
2. Measure building front offset, building front, along property front
3. Mark exact points with 2" x 2" stakes and 8d finish nails
4. Stretch depth offset lines perpendicular to property front at each point marked
5. Measure building depth offset, building depth along each of these lines from points marked
6. Mark depth offsets, building depths with 2" x 2" stakes and 8d finish nails — (4) points

CHECK POINTS: Check the big square/rectangle:

A. Overall building outline dimensions
B. Diagonal corners equal distance

7. Mark undesirable vegetation for removal with bright red ribbon streamers plainly visible
8. Mark unwanted structures for removal with red paint plainly visible

9. Mark caution areas such as underground pipes, utilities with surveyor's laths and yellow streamers
10. Mark desired structures; vegetation with blue streamers plainly visible

CHECK POINTS: Check with instructor before clearing commences

INSTRUCTOR'S PLAN
MANIPULATIVE LESSON

II-A-3(S)

TASK:	Establish TBM (Temporary Bench Mark)
AIM:	The students will be able to select and establish a temporary bench mark and accurately determine its elevation.
TOOLS AND EQUIPMENT:	Builder's level or transit-level, tripod, level rod, 3 lb. engineer's hammer or light sledge hammer
MATERIALS:	Permanent paint and small paint brush, or RR spike, surveyor's lath, and permanent marker or lumber keel
TEACHING AIDS:	Project blueprints and plot plan
REFERENCES:	Elementary Surveying, Chpt. 5.
PREREQUISITE EXPERIENCE OF THE LEARNER:	
CHECKING STANDARDS:	1. Selection of TBM 2. Transit technique and procedure 3. Care of transit, tripod, level rod 4. Accuracy in performing job 5. Work attitude 6. Field safety practices

---

I. PREPARATION (OF THE LEARNER-MOTIVATION)

The establishment and use of a temporary bench mark may or may not be necessary for the setting of grades and vertical controls of a building project.

This must be determined by the person doing the work, and this judgement is based on the situation. Generally, on fairly level ground where sight distances are not too great or obstructed, it is not necessary. Grades and elevations can be set from the permanent bench mark (BM). On the opposite hand, when the terrain is too hilly, and sight distances too great or obstructed, establishing a TBM and working from it to set grades and elevations is a must.

A quick check can be made to determine whether a TBM is necessary if visual inspection does not obviously indicate the fact. Simply station the level where you think all points of the grade site and the BM can be seen. First, have the rodman place the rod on the BM and check line of sight with the transit telescope. Second, have rodman place rod at the extremes of the grade site and check lines of sight in the same manner. If the level rod can be read easily at these points a TBM is not necessary; if it cannot be read, a TBM must be employed.

II. PRESENTATION (OF THE SKILLS)

STEPS	KEY POINTS (THINGS TO REMEMBER TO DO OR SAY)
1. Locate Grade Control References	1. On blueprint plot plan a. Permanent landmark noted "BM" b. Description, location, elevation given Examples: BM-Top of concrete curb-El. 316.15' BM-Top of fire hydrant-El. 318.65' 2. On building site a. Visually identify b. Description, location as per plot plan c. Exact spot marked with "X"; BM and elevation noted
2. Select Temporary Bench Mark (TBM)	1. On well defined permanent, field object Examples: Large stone; concrete monument; large tree trunk; lateral root 2. Near actual building location 3. Convenient for general view of site
3. Mark Exact Spot	1. On stone, monument-mark "X" with permanent paint 2. On tree trunk, pole-drive RR spike horizontally near base to accommodate lining rod 3. On lateral root-cut horizontal notch and set RR spike in flat surface
4. Position Transit	1. So that sight distances are approximately equal from a. Transit to BM b. Transit to TBM 2. For clear sight to both BM and TBM 3. Set up and level transit (previous lesson) Note: Plumb bob not necessary this operation!
5. Establish Height of Instrument	1. Set level rod on BM a. "O" end down b. Centered on BM c. Visually plumb (vertical) 2. Train telescope on rod a. Loosen horizontal motion b. Rotate telescope (lens end) toward rod c. Adjust focus as required d. Plumb rod with vertical cross-hair

3. Read lowest rod level
    - a. Rodman tilt rod back and forth slowly
    - b. Read nearest hundredth-of-a-foot
    - c. At horizontal cross-hair

4. Calculate height of instrument

Example:
316.15' BM-T.O.C. Curb
+4.32' Rod Reading
320.47' HI

6. Establish TBM Elevation

1. Set level rod on TBM similar as in step #5
2. Sight on rod similar as in step #5
3. Read rod to nearest hundredth-of-an-inch
4. Calculate TBM

Example:
320.47' HI El.
-2.62' Rod Reading
317.85' TBM El.

7. Mark To Identify

1. With surveyor's lath on tree or pole
    - a. Nail to tree or pole
    - b. Just above TBM
    - c. With arrow (wedge end) down
2. Mark with keel or lumber crayon
    Example: TBM El. 317.85'
3. With permanent paint on stone, concrete
    - a. Exact spot with an "X"
    - b. Label "TBM" and "elevation"

III. APPLICATION (PRACTICE BY LEARNER UNDER CLOSE SUPERVISION)

Instructor set up problems in hilly terrain.

Students practice establishing TBM elevations using job and task sheets.

IV. VERIFICATION AND/OR EVALUATION (CHECK ON STUDENT'S ABILITY)

Performance Test!

Students perform job and tasks on actual job site to acceptable accuracy for construction purposes.

V. SUMMARY (TELL THE STEPS ON PROCEDURE AS TO WHAT, HOW, AND WHY. REVIEW CHECKING STANDARDS. THIS SUMMARY MAY BE GIVEN AT ANY PLACE IN THE LESSON THE TEACHER FEELS WILL BE PROFITABLE TO THE STUDENTS.)

1. Locate bench mark(s) as per plot plan

2. Select and mark temporary bench mark
   a. On a well defined permanent field object
   b. Near all building locations
   c. Convenient view of site
3. Position transit-level
   a. For clear sight to both BM, TBM
   b. Sight distances approximately equal
4. Establish height of instrument
   a. From BM elevation
   b. Plus reading of rod set on BM
5. Establish TBM elevation
   a. From HI
   b. Minus reading of rod set on TBM
6. Mark TBM and elevation

SUGGESTED READING FOR THE STUDENT: None

The Next Lesson Is: II-A-4(S), "Set Grade Stakes"

JOB SHEET
IN
BUILDING SITE PREPARATION

NAME OF JOB: Establish T. B. M. (Temporary Bench Mark)

DRAWINGS: Blueprint plot plan

MATERIALS: Railroad spike, paint or permanent marker, surveyor's lathe, 6d common nails

TOOLS AND EQUIPMENT: Builder's level, level rod, tripod, 3 lb. engineer's hammer

GENERAL INSTRUCTIONS: Selection of the T. B. M., placement and set up of the instrument, and accurate readings are important factors in establishing a T. B. M. Review information sheet II-A-3(IS) before commencing this job.

PROCEDURE AND/OR TASK:

1. Locate B. M. — as per plot plan data
2. Select T. B. M. — permanent field object near actual building location such as top of concrete curb or monument; bare tree trunk
3. Mark exact spot — with permanent paint, mark "X" on top of curb or monument; with railroad spike driven laterally in tree trunk to accommodate lining rod
4. Set up and level instrument — as per II-A-1a(TS) so that sight distances are approximately equal to B. M.; to T. B. M.
5. Establish H. I. (Height of Instrument) — shoot/read vertical rod on B. M.; add to B. M. elevation
6. Establish T. B. M. elevation — shoot/read vertical rod on T. B. M.; subtract from H. I.
7. Mark to Identify — "T. B. M." and "elevation" on concrete or stone; on surveyor's lath nail to tree above spike

INSTRUCTOR'S PLAN
MANIPULATIVE LESSON

TASK: Set Grade Stakes

AIM: The students will be able to establish a grid system on a building site, calculate new grade elevations and set, cut and/or fill stakes to guide and control earthwork to desired building grades.

TOOLS AND EQUIPMENT: Builder's level or transit level, tripod, level rod, (2) 100' measuring tapes, engineer's hammer or light sledge hammer, nylon string or strong cord

MATERIALS: 2x4x8" lg. grade stakes, 2x4x16" lg. guard stakes, surveyor's laths, ribbon flagging

TEACHING AIDS: Project plot spans, tracing paper, architect's and/or engineer's scale, pencils, note pad

REFERENCES: The World of Construction, pp. 182-188

PREREQUISITE EXPERIENCE OF THE LEARNER: The student must have successfully completed previous lessons

CHECKING STANDARDS:

1. Correct procedures; techniques
2. Proper use, care of leveling instrument, tools, and equipment
3. Accuracy of computations; measurements; readings
4. Safe, efficient production
5. Interest in successful completion of tasks; attitude

---

1. PREPARATION (OF THE LEARNER - MOTIVATION)

Clearing and grading can be, and often is, conducted in one operation. We have chosen to discuss each separately, for each has tasks unique unto itself, and often these operations are conducted separately, allowing time to remove, burn, or otherwise rid the site from the debris of clearing, between operations. Much depends on the situation at hand; the extent of clearing required, timetables and economics, local ordinances, etc. Each builder must study the total situation and determine an appropriate procedure based on that situation.

Once the building site has been cleared of all undesirable vegetation, debris, and structures, it is ready for grading. Grading is the shaping of the earth's topography to cause a level area for building foundations, and a gentle sloping around the foundations for drainage and landscaping. Here again, the method of grading must be determined by the situation at hand.

The methods of grading range from the simple, where the heavy equipment operator works from the verbal instructions of the builder and uses his skill in moving, leveling, and sloping the earths surface to a desired circumstance (this usually occurs on small, open, relatively level plots), to the complicated, where the topography is erratic and must be altered drastically.

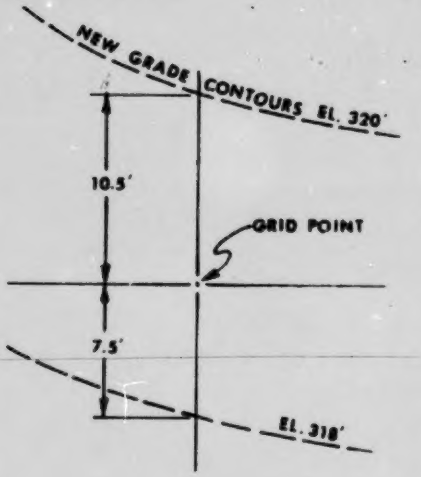
Any method however, calls for some type of grade controls. Often grade controls must be established more than once during the grading operation. Specifications may call for stripping and storing topsoil to be used on final grade; extensive moving (rearranging) of existing fill may be necessary; additional compactable fill may be required. Generally, grade control is a two phase process: (a) setting cut and fill stakes for rough grading; (b) setting blue top stakes for final grade.

The following lesson is one procedure for establishing grade controls. In addition to setting grade stakes, students will assist the sub-contractor upon request and observe actual grading. Remember to stay alert at all times when you are around heavy equipment in operation.

II. PRESENTATION (OF THE SKILLS)

STEPS	KEY POINTS (THINGS TO REMEMBER TO DO OR SAY)
1. Determine Grid System	1. From site inspection 2. From blueprint plot plans a. Study original grade contours and topography b. Study final grades and elevations 3. Establish grid spacing a. Appropriate to overall size of building site b. Appropriate to contour lines spacing and elevations Note: Typical grid spacing for most urban sitework is 25'. This figure will be used in illustrations throughout the lesson
2. Make Grid Drawing	1. To same scale as plot plan 2. On plot plan with colored pencil, or ... 3. On tracing paper overlay of plot plan 4. Draw: a. Grid lines parallel to property front b. Grid lines perpendicular to property front c. Grid lines on 25' spacing - or as predetermined in step #1 d. Start at property front corner 5. Number grid points (intersection of grid lines) to identify

3. Calculate New Grade Elevations



1. At grid points, one-at-a-time
2. Measure on drawing
   a. From grid point
   b. To new grade contour each side
   c. Along grid line

Example: 7.5' (measured) to 318' contour
+10.5' (measured) to 320' contour
18' total distance between contours

3. Determine difference in elevations of contours

Example: 320' - 318' = 2' total elevation between grade contours

Note: New grade elevation = proportional difference; distance to elevation

4. Set up ratio and cross multiply

Example: $\frac{7.5}{18} \Big| \frac{X}{2}$, $18X = 15$, $X = .83$

5. Add proportional difference to lower contour elevation for new grade elevation

Example: 318' + .83 = 318.83'

6. Record new grade elevation on grid drawing

4. Layout And Stake Grid System

1. On building site
2. Same as grid drawing
   a. Grid lines parallel to property front
   b. Grid lines perpendicular to property front
   c. Grid lines of 25' intermals

A. Layout And Stake Base Lines

1. One line on property front boundary
2. One line perpendicular to property front boundary
3. From common boundary corner
4. Visually lined or string lined
   a. Measure 25' intervals
   b. To opposite boundaries
5. Set 8" stakes
   a. At each 25' interval
   b. Driven flush with ground
6. Set 16" guard stake (optional)
   a. 6" into ground
   b. At a slant
   c. Over grid stake
7. Set flagged lath
   a. Adjacent each grid stake
   b. Approximately 6" deep or until held firm

B. Layout And Stake Interior Grid Points

1. From baseline grid points
2. With two (2) measuring tapes

- a. One tape on each base line
- b. At coordinate points on base line
- c. Tape lengths set at appropriate 25' increments

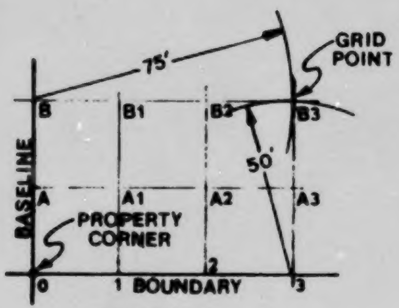
3. Swing arcs to intersect on property

Note: Intersection of tapes marks interior grid point

Example:

50' tape @ 3rd. point, front base line (0+75')
75' tape @ 2nd. point, depth base line (0+50')
Arcs intersect at grid point 3 x 2 units

4. Set 8" stake and flagged lath
   - a. At each interior grid point
   - b. As each grid point is located
   - c. Same as step #4A
5. Continue locating and marking interior grid points one-at-a-time until grid layout is complete



25' GRIDS

5. Set Up And Level Transit

1. Similar as in lesson II-A-1(S)

Note: Use of plumb bob is not necessary

2. Conveniently located near center of plot
   - a. With good site view-all grid points
   - b. With good site view-TBM (or BM if used)

Check Point:

Double check following:

1. Instrument level - through 360° rotation
2. Clear line of sight - grid points; TBM

6. Establish Height of Instrument

1. From TBM, or BM (whichever is used)
2. Position level rod
   - a. On TBM
   - b. Point down on exact spot
   - c. Held vertically
3. Sight telescope on rod
   - a. Loosen lower horizontal motion clamp screw
   - b. Rotate telescope to align vertical cross-hair with level rod
4. Read rod
   - a. Adjust focus as necessary
   - b. Plumb rod with vertical cross-hair
   - c. Read closest hundredth-of-a-foot at horizontal cross-hair
5. Calculate height of instrument
   - a. TBM elevation
   - b. Plus rod reading

  - c. Equals height of instrument

Example: 317.85' TBM El.
+ 5.12' Rod reading
322.97' H.I.

7. Shoot Existing Grade Elevation

1. At grid points, one-at-a-time
2. Position level rod
   - a. On top of stake flush with ground
   - b. Point down
   - c. Held vertical
3. Shoot rod
   - a. Sight telescope on rod
   - b. Plumb rod with vertical cross-hair
   - c. Read closest hundredth-of-a-foot at horizontal cross-hair
   - d. Record reading
4. Calculate existing grade
   - a. Height of instrument
   - b. Minus rod reading
   - c. Equals existing grade

Example: 322.97' H.I.
- 4.89' Rod reading
318.08' Existing grade el.

5. Record existing grade, each grid point as calculated

8. Determine Cut or Fill

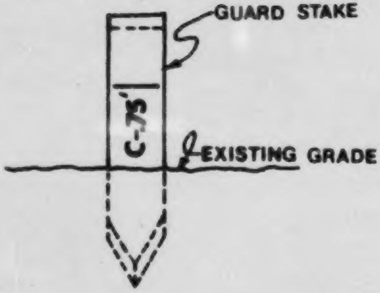
1. At each grid stake, one-at-a-time
   - a. From new grade computations (step #3)
   - b. Take difference of existing grades (step #7)

Example: 318.83' New grade
318.08' Existing grade
.75' Fill

Note: If new grade is greater than existing grade, the difference is "fill".
If new grade is less than existing grade, the difference is "cut".

2. Record calculations, cut or fill, each grid point

9. Mark Cut or Fill



1. On surveyor's lath, or guard stake if used
2. With heavy lumber crayon or permanent marker
   a. Mark horizontal line on lath or stake plainly visible
   b. Mark cuts with a "C" and "amount" below the line
   c. Mark fills with an "F" and "amount" above the line

Note: If top soil has been stripped and stored for final grade, rough grade should be set 4" - 6" less as specifications require

10. Oversee Grading

1. Locate and control stockpiles
   a. Outside construction area
   b. In area requiring little or no cut or fill
2. Advise grading equipment operator on request
   a. Initial cuts and fills
   b. Visual checks - rough grade profile
3. Assist and advise
   a. Maintain key grade stakes
   b. Make interim grade checks upon request
4. Observe grading operation

Note: Upon completion of rough grading, proceed with second phase; setting blue top stakes for final grade

11. Re-establish Grid System

1. Similar as per step #4, this lesson
2. With 12" long "blue top" stakes
   a. Set vertically at all grid points
   b. Tops approximately 9" above ground (rough grade)

12. Set Up And Level Instrument

1. Similar as per step #5, this lesson

13. Establish Height of Instrument

1. Similar as per step #6, this lesson

14. Set tops of Stakes

1. To final grade elevation
2. One-stake-at-a-time
3. As follows:

A. Determine Top of Stake Elevation

1. Similar as per step #7, this lesson
2. Position level rod
   a. On blue top of stake
   b. Point down
   c. Held vertical
3. Shoot rod
   a. Sight telescope on rod

b. Plumb rod with vertical cross-hair
c. Read rod to closest hundredth-of-a-foot at horizontal cross-hair

Example: 5.52'

4. Calculate elevation, top of stake
   a. Height of instrument
   b. Minus rod reading
   c. Equals top of stake elevation

Example: 324.68' H.I.
- 5.52' Rod reading
319.16' Top of stake El.

B. Determine Difference In Elevations

1. Top of stake elevation
2. Minus finish grade elevation (as calculated in step #3, this lesson)
3. Equals difference in elevations

Example: 319.16' top of stake El.
318.83' final grade El.
.33' difference El.

C. Determine Rod Reading

1. To set tops of stakes
2. To final/finish grade elevation
3. By computation, one stake-at-a-time
   a. Top of stake reading
   b. Plus difference in elevations
   c. Equals rod reading

Example: 5.52' Top of stake rod reading
+.33' Difference
5.85' Rod reading for site grade

D. Set Tops of Stakes

1. With engineer's hammer
2. Drive stakes a little at a time
3. With interim grade checks
   a. Using level instrument
   b. Read level rod
   c. Until rod reading matches computations as calculated in step #14 - C above

15. Oversee Grading

1. Similar as step # 10, this lesson

III. APPLICATION (PRACTICE BY LEARNER UNDER CLOSE SUPERVISION)

1. Students become familiar with steps and keypoints from task sheets.
2. Students practice:
   a. measurements with engineer's scale
   b. measurements with surveyor's steel tapes
   c. locating a point by intersecting measurements from given points

3. Students reinforce skills with engineer's level, level rod
    a. shooting, plumbing rod
    b. reading rod

IV. VERIFICATION AND/OR EVALUATION (CHECK ON STUDENT'S ABILITY)

Performance Test!

1. Students prepare grid drawing to same scale as plot plan.
2. Students calculate new grade elevations at grid points.
3. Students layout and stake building site for rough grade.
4. Students layout and stake site for finish grade.

V. SUMMARY (TELL THE STEPS ON PROCEDURE AS TO WHAT, HOW, AND WHY. REVIEW CHECKING STANDARDS. THIS SUMMARY MAY BE GIVEN AT ANY PLACE IN THE LESSON THE TEACHER FEELS WELL BE PROFITABLE TO THE STUDENTS.)

There are many methods of preparing the building site for construction. Often, clearing and grading are conducted in one operation. The method must be tailored to meet the circumstance of each given site. Economics, schedules and timetables, and city ordinances influence the method or procedure chosen.

Regardless of the procedure used, there must be some form of grade control; a guide, or directions by which the grading equipment operators bring the earth's topography to the required condition for the building construction intended.
Generally, grade control is a two phase process: (a) setting cut and fill stakes for rough grade; setting blue top stakes for final grade.

The first step is to design an effective grid system for setting grade stakes. A grid drawing is made to the same scale as the blueprint plot plan to overlay the plot plan, and new grade elevations at the grid points calculated. (NOTE: If topsoil is stripped and stored for final grade, the calculated elevations must be reduced 4" - 6" as specifications require for redistribution of topsoil at final grade.)

Second, the grid system must by laid out on the building site and all grid points marked with 8" long grade stakes flush with the ground, protected by guard stakes, and marked with flagged surveyor's lath.

The calculated cut or fill must then be determined and marked on the guard stake (or flagged lath) at each grid point. This is done by setting up the level instrument in a central location; obtaining the H.I. from the BM or TBM; obtain rod reading at each grade stake one-at-a-time; calculate existing grade elevation; and determine difference in existing grade and new grade. (NOTE: If new grade is greater than existing grade, the difference is "fill". If new grade is less than existing grade, the difference is "cut").

Upon completion of rough grading the grid system should quickly be re-established and grid points marked with 12" long blue top stakes set vertically with tops exposed 8" - 9".

The tops of these stakes must then be determined, (this is done in the same manner as were the 8" grade stakes) and the difference in the top of stake elevation and final grade (new grade calculation) must be computed.

The blue top of the finish grade stakes must be set for final grade elevation. This is done by adding the difference in elevation just computed (each stake), to the rod reading (each stake), and driving the stakes a little at a time until the corrected rod reading is reached using interim checks with the level instrument and level rod.

As actual grading is done, assistance and advice should be provided equipment operators upon request. Remember to be alert at all times when around heavy equipment in operation.

SUGGESTED READING FOR THE STUDENT :

Modern Carpentry, pp. 43-51, and pp. 88-94
Fundamentals of Carpentry, pp. 43-49, pp. 64-74

The Next Lesson Is: II-A-5(S), "Layout Building Lines And Erect Batter Boards"

II-A-4(J)

JOB SHEET
IN
BUILDING SITE PREPARATION

NAME OF JOB: Set Grade Stakes

DRAWINGS: Blueprint plot plan, floor plan, and elevations

MATERIALS: 2" x 4" x 8" lg. grade stakes, 6d finish nails, tracing paper, pencil and pad, 2" x 4" x 16" lg. guard stakes, ribbon flagging, permanent marker, surveyor's laths, nylon cord, field notebook

TOOLS AND EQUIPMENT: Builder's level, 100' steel measuring tapes (2), tripod, 3 lb. engineer's hammer, level rod, architect's or engineer's scale, straight edge

GENERAL INSTRUCTIONS: Grading is the reshaping of the earth's topography to cause a level area for building foundations, and a gentle sloping around the foundations for drainage and landscaping. The extent of grading depends on the existing topography and, of course, the architect's design. Grading can be almost negligible or very extensive. Any amount of grading, however, calls for some type of grade controls.

The setting of grade stakes is used extensively in residential and small commercial construction and is generally done in two phases: (a) setting cut and fill stakes for rough grade; (b) setting blue top stakes for final grade.

PROCEDURE AND/OR TASK:

II-A-4(TS)	Lay Out And Stake Grid System
II-A-4a(TS)	Shoot Existing Grades
II-A-4b(TS)	Calculate New Grades; Cut And Fill
II-A-4c(TS)	Mark And Set Grade/Guard Stakes

TASK SHEET

II-A-4(TS)

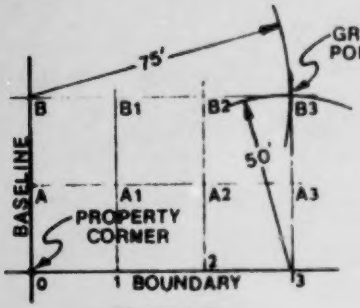
TASK:	Lay Out And Stake Grid System
JOB:	Set Grade Stakes
TRADE:	Building Trades
TOOLS AND MATERIALS:	Tracing paper, nylon cord, 6d finish nails, architect's scale (2) 100' measuring tapes, straight edge 2" x 2" 8" lg. stakes, pencil (2H, sharp), 3 lb. engineer's hammer

TASK BREAKDOWN:

STEPS	KEY POINTS
1. Determine Grid Spacing	1. From site inspection a. Overall size, shape b. Existing topography 2. From blueprint plot plan a. Existing grade contours b. New grade contours 3. Spacing appropriate to: a. Contour lines spacing and elevations b. Overall size of building site
2. Make Grid Drawing	1. To same scale as plot plan 2. On tracing paper overlay of plot plan a. Lay out grid lines parallel to property front boundary b. Lay out grid lines perpendicular to property front boundary 3. Start at property front corner 4. Number grid points (intersection of grid lines) to identify
3. Lay Out And Stake Base Lines	1. On property site 2. Start at property corner 3. Lay out base lines a. One line on property front boundary b. One line perpendicular to property 4. Measure and mark grid intervals along base lines a. With 2" x 2" x 8" lg. stake flush in ground b. With 6d nail in top of stake-exact spot

STEPS | **KEY POINTS**

4. Lay Out And Stake Interior Grid Points


GRID POINT
75'
B
B1
B2
B3
50'
BASELINE
A
A1
A2
A3
PROPERTY CORNER
0
1
2
3
BOUNDARY

25' GRIDS

1. From base line grid points
2. With (2) measuring tapes
   a. One tape on each base line
   b. At coordinate points on base lines
   c. Tape lengths set to appropriate length
3. Swing arcs to intersect on property
4. Mark point of intersection
   a. With 2" x 2" x 8" lg. stake flush in ground
   b. With 6d nail in top of stake-exact spot

TASK SHEET

II-A-4a(TS)

TASK: Shoot Existing Grades

JOB: Set Grade Stakes

TRADE: Building Trades

TOOLS AND MATERIALS: Builder's level, pencil, level rod, field notebook

TASK BREAKDOWN:

STEPS	KEY POINTS
1. Set Up And Level Instrument	1. As per II-A-1a(TS) 2. Within good sight view of TBM (or BM if used) 3. Within good sight view of all grid points
2. Establish H.I.	1. Position level rod vertically on TBM 2. Shoot rod and obtain reading 3. Calculate H.I. — "reading" plus "TBM elevation" 4. Record H.I.
3. Shoot Existing Grades	1. Position level rod vertically on each grid stake one-at-a-time 2. Shoot rod and obtain reading 3. Subtract reading from H.I. elevation
4. Record Existing Grade Elevations	1. In field notebook 2. To correspond with grid point I.D. number

Example: GRADE EVALUATIONS

GRID	EXIST	NEW	DIFF.
B3	318.08'		

TASK SHEET

II-A-4b(TS)

TASK: Calculate New Grades; Cut And Fill

JOB: Set Grade Stakes

TRADE: Building Trades

TOOLS AND MATERIALS: Architect's scale, field notebook, pencil and pad

TASK BREAKDOWN:

STEPS	KEY POINTS
1. Measure Grid Drawing Overlay (See Sketch Next Page)	1. Of plot plan 2. From each grid point one-at-a-time 3. To new grade contour lines 4. Each side of grid point 5. Use appropriate scale Example: 7.5' (measured) to 318' contour 10.5' (measured) to 320' contour 18' total distance between contours
2. Calculate Difference In Contour Evaluations	1. At grid point in question 2. Subtract smaller "new contour" elevation from larger "new contour" elevation Example: 320' — 318' = 2'
3. Calculate Grid Point New Elevation	1. New grade elevation at grid point equals proportion difference; distance to elevation 2. Set up ratio and cross multiply Example: $\frac{7.5'}{18'} \Big/ \frac{X}{2'}$, $18X = 15$, $X = .83'$ 3. Add proportional difference to lower contour elevation Example: 318' + .83' = 318.83'
4. Record New Grade Elevation	1. In field notebook 2. To correspond with grid point I.D. number Example: GRADE ELEVATIONS

GRID	EXIST	NEW	DIFF.
B3	318.08'	318.85'	

STEPS	KEY POINTS

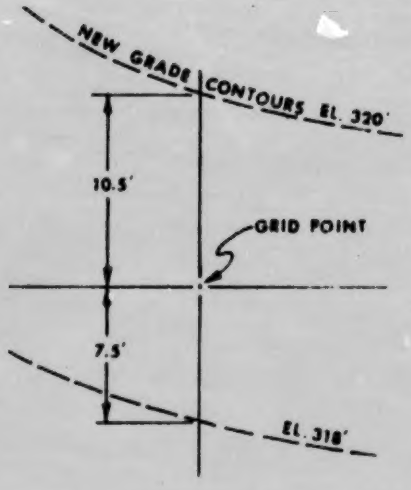
5. Calculate "Cut And Fill"

1. Compare "existing, new" elevations
    - a. When existing elevation is greater than new elevation, the difference is "cut"
    - b. When existing elevation is less than new elevation, the difference is "fill"
2. Take difference of new and existing grade at each grid point

Example:

new grade	318.83'
exist. grade	318.08'
Fill	.75'

6. Record Cut And Fill



1. In field notebook
2. Use "C" or "F" and elevation difference
3. At each grid point
4. To correspond with grid point I. D. number

Example: GRADE ELEVATIONS

GRID	EXIST	NEW	DIFF.
B3	318.08'	813.85'	F.75'

Note: If top soil has been stripped and stockpiled for final grade, rough grade should be 4" less or as specifications require. Add 4" to difference of all cuts. Subtract 4" from difference of all fills

TASK SHEET

II-A-4c(TS)

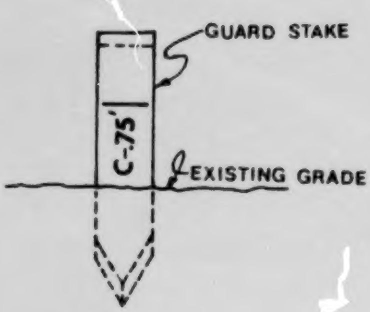
TASK: Mark And Set Grade/Guard Stakes

JOB: Set Grade Stakes

TRADE: Building Trades

TOOLS AND MATERIALS: 2" x 4" x 16" lg. stakes, 3 lb. engineer's hammer, permanent marker, surveyor's lath and flagging (optional)

TASK BREAKDOWN:

STEPS	KEY POINTS
1. Distribute Stakes	1. 2" x 4" x 16" lg. stakes 2. To all grid points 3. One stake per grid point
2. Mark Stakes 	1. Systematically 2. One stake at-a-time 3. To correspond with grid point I. D. number 4. Near upper end: a. Mark horizontal line plainly visible b. Mark "cuts" with a "C" and "amount" below the line c. Mark "fills" with an "F" and "amount" above the line 5. Use permanent marker 6. Use bold letters/numbers (3" high)
3. Set Stakes	1. As each is marked 2. 6" into ground 3. At a slant over grid stake 4. With marks face up toward property front
4. Set Flagged Lath (Optional)	1. Adjacent each grid stake 2. Vertical in ground 3. Approximately 6" deep or until held firm

INSTRUCTOR'S PLAN
MANIPULATIVE LESSON

II-A-5(S)

TASK:	Lay Out Building Lines And Erect Batter Boards
AIM:	The students will be able to precisely lay out building lines and erect batter boards for both horizontal and vertical control of building construction.
TOOLS AND EQUIPMENT:	Builder's level or transit level, tripod, level rod, lining rod, (2) 100' measuring tapes, engineer's hammer, claw hammer, cross-cut hand saw, stringlines (nylon cord), (2) plumb bobs
MATERIALS:	2" x 2" x 12" hub stakes, 2" x 4" x 3'-0 offset stakes, 1" x 6" x 8'-0 ledger boards, 8d finish nails, 8d common nails
TEACHING AIDS:	Blueprint plot plan, local building codes and restrictions, note pad, pencils
REFERENCES:	Modern Carpentry, pp. 87-90
PREREQUISITE EXPERIENCE OF THE LEARNER:	The student must have successfully completed
CHECKING STANDARDS:	1. Proper use, care of tools, equipment 2. Efficient use of time, materials 3. Follows acceptable building procedures 4. Accuracy in layout and measurement 5. Work attitude - works well with others; interest in safe completion of job

---

I. PREPARATION (OF THE LEARNER - MOTIVATION)

The blueprint plot plan shows exactly where the building will be in relation to the property. This is done by showing the building outline (in plan) with key dimensions locating it from property lines or other property features.

The outside faces of the foundation walls are called building lines. The main outside walls are used as reference; baselines from which subsidiary portions of the building are laid out, and to which the building location dimensions are made.

The actual layout of the building on the property site may be accomplished much as in previous lesson II-A-2(S). The exception being, "it must be done with precision". For this reason most builders use the same, or similar method but employ the use of a builder's transit level to shoot lines and turn angles with extreme accuracy.

Even after the building lines have been established and the building corners precisely marked on the ground (corner hubs), the builder must erect batterboards and transfer all outside building lines to these batterboards' ledgers with equal precision since all ground marks are quickly lost when excavation and form construction commence. Batterboards are erected well outside the building lines so that they will not be disturbed by excavation and construction. Properly constructed batterboards serve a two-fold purpose: (1) horizontal building control, and (2) vertical building control.

Horizontal control is accomplished by very accurately transferring the building lines from the ground markers to the batterboards' ledgers. Use of plumb bobs and a mason's line stretched over the building lines are employed for this purpose. The ledger boards are marked to the stretched line so that these lines may be removed/ replaced as necessary. All buildings are built to lines. Accurately marked lines and ledgers insure that the building will be properly located; walls straight; corners square, and dimensions precise.

Vertical building control may be incorporated into the construction of the batterboards by simply setting the ledger's level at a given elevation; generally "top of concrete" elevation. In this way the concrete forms for the foundation wall or slab foundation may be built to a string line stretched between ledgers thus maintaining a straight, flat, and level foundation.

Study the blueprint plot plan and foundation plans carefully; perform the job and tasks precisely, and double check for accuracy, as any mistake at this point could cause extensive rework and time delays which could make the difference in your company's future, and your job.

II. PRESENTATION (OF THE SKILLS)

STEPS	KEY POINTS (THINGS TO REMEMBER TO DO OR SAY)
1. Study Builder's Plans	1. Become familiar with plans; specifications a. Lay of the land, size, shape b. Property easements, restrictions c. Building size, shape, outline d. How building is located with reference to property lines; features 2. Determine a. Main building lines b. How referenced to property c. Best procedure to lay out building lines on property d. Where to erect batterboards
2. Re-establish Property Front Boundary	1. As per lesson II-A-1(S), steps 2 thru 9 Note: Property corners should have been protected during clearing and grading operations. If this is so proceed as follows:

2. Stretch nylon string
    - a. Straight and taut
    - b. Between property front corners
    - c. Tie to nail in corner hubs

3. **Measure And Mark Main Building Front Offsets**

Note: Front offset markers may have been preserved from previous building layout. If so, check as follows and adjust as necessary.

A. Measure Offsets

1. Very accurately
2. With steel measuring tape
    - a. Tape straight and flat
    - b. Tape held taut
3. From property corner
4. Along front property line
5. Dimensions as per plot plan
    - a. Building front offset
    - b. Building front length

B. Mark Offsets

1. With 2" x 2" x 12" long hub stake
    - a. Driven vertically into ground
    - b. Approximately 10" deep
    - c. Directly under string line
    - d. At point of measurement
2. Set 8d nail
    - a. In top of stake
    - b. At exact point measured and string line
    - c. With head of nail exposed 1/2"

4. **Set Up Transit Level**

1. Over front offsets
2. One-at-a-time
3. Similar as per lesson II-A-1, step 4
    - a. Set up tripod
    - b. Mount transit and affix plumb bob

A. Position Transit

1. Over offset marker
2. About chest high
3. With tripod legs spread 3'-4' apart

Note: Two legs downhill on sloping ground

4. Visually level; visually center
    - a. Move legs slightly as required
    - b. So that plumb bob suspends within 1/4" of offset mark (nail head)
5. Set tripod feet firmly

B. Center Transit

1. Loosen two adjacent leveling screws
2. Shift leveling head spider slightly as required

3. To move plumb bob over dead center of offset mark (nail head)
4. Tighten same two leveling screws

C. Level Transit

1. Check vertical arc vernier
   a. Loosen vertical motion clamp screw
   b. Set vertical arc vernier on 0°
   c. Tighten vertical motion clamp screw
2. Loosen horizontal motion clamp screw
3. Rotate telescope to align over two opposing leveling screws
4. Tighten horizontal motion clamp screw
5. Face side of telescope with level tube
6. Turn leveling screws (2)
   a. Aligned with telescope
   b. In opposite directions
   c. Simultaneously
   d. With thumb and forefinger, each hand
7. Observe bubble in spirit level

Note: Bubble will follow direction of movement of left hand

8. Bring telescope to level position (bubble between lines on level tube).
9. Loosen horizontal clamp screw
10. Rotate telescope 90° to align over opposite two leveling screws
11. Tighten horizontal motion clamp screws

Note: Repeat key points 2 thru 11 until spirit bubble remains level thru 360° rotation

D. Orient Transit

1. With property front boundary
2. Loosen both horizontal motions (clamp screws)
3. Set plates to read approximately 0°
   a. Hold upper plate in position
   b. Turn lower plate using tangential pressure from under side

Note: Approach, but do not pass 0°

4. Tighten upper motion clamp screw (snug)
5. Set vernier 0° exactly opposite plate 0°
   a. By means of upper tangent screw
   b. Use positive clockwise motion only
   c. Do not go beyond 0° setting
6. Rotate telescope to align with property front boundary
   a. With both hands on plate edge or standards

   b. Rough sight along top of telescope barrel
   c. Finish sight looking through telescope
   d. Vertical cross-hair to align with property front boundary (stringline, taut)
7. Tighten lower motion clamp screw (snug)

Check Point:

Check: Property front offset accurately located
Transit centered over property front offset
Transit is level
Horizontal vernier is set 0°
Telescope vertical cross-hair aligned with property front boundary line
The transit is oriented!

5. Turn Building Depth Offset Angle

1. With transit telescope
2. Into property depth
3. Using horizontal vernier
   a. Loosen upper horizontal motion clamp screw
   b. Turn upper plate in direction to form angle
   c. Read vernier to approach, but not pass, 90° angle
   d. Tighten upper horizontal motion clamp screw
   e. Set exact angle with horizontal tangent screw
      (1) In same positive direction angle was turned
      (2) Read degrees on circle; minutes on vernier

6. Measure Depth Offsets

1. With steel measuring tape
   a. Held straight, flat, and taut
   b. Aligned with telescope vertical cross-hair
2. From property front offset
3. Along depth offset line
4. Dimensions as per plot plan
   a. Building depth offset
   b. Building depth
5. Very accurately

7. Mark Depth Offsets

1. With 2" x 2" x 12" long hub stake
   a. Drive vertically into ground 10" deep
   b. Directly on line at points measured

2. Mark exact length across top of stake
    a. With pencil positioned next to tape
    b. Swing arc across top of stake
3. Position 8d finish or scribed line
4. Align nail with telescope vertical cross-hair
5. Set nail vertically in top of stake
    a. Very accurately
    b. With nail head exposed 1/2"

Note: Building depth offsets (two each line) represent the four corners of structure's main building lines

Check Point:

Check: Building length dimensions to be correct
Building depth dimensions to be correct
Building layout to be square (diagonal dimensions equal)

Note: The following steps is an alternate procedure for laying out the building overall size on the property. It may also be used to check previous building layout

8. Locate Building Depth Offset, Building Depth One Side

Repeat steps #1 thru #7, this lesson

1. Study builder's plans
2. Re-establish property front boundary
3. Measure and mark building offset on property front boundary
4. Set up, center, level transit over front offset; orient transit to front property line
5. Turn building depth offset angle (90°)
6. Measure depth offsets
7. Mark depth offsets

Note: Building depth offsets are also building corner hubs

9. Move Transit

1. To first building depth offset (also building front corner)
2. Practice proper handling/carrying technique with tripod mounted transit

10. Set Up Transit

1. Centered over front building corner
2. Level as per step #4-C, this lesson
3. Orient transit
    a. Telescope vertical cross-hair aligned with building depth line and back corner hub
    b. Horizontal vernier set at 0°

11. Turn Angle And Shoot Building Front Line

1. With transit telescope
2. Turn angle in direction as per plot plan (90°)
   a. Use horizontal vernier to set angle
   b. Use vertical cross-hair to set building line

12. Measure And Mark Next Building Corner

1. With steel measuring tape
   a. Aligned with telescope vertical cross-hair
   b. Held straight and taut
2. With 2" x 2" x 12" long hub stake
   a. Driven vertically into ground
   b. At point of measurement
3. With 8d finish nail
   a. Set in top of stake
   b. At exact point

Note: Continue to move transit to new corner hub; set up transit; sight on building line just located; turn angle as per plot plan and shoot next building line; measure and mark new corner hub until main building lines form a closure at first building corner located

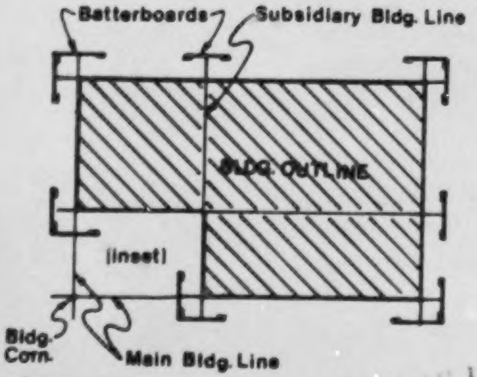
13. Measure And Mark Subsidiary Building Lines, Corners

1. From main building corner hubs
2. Along main building lines
3. As per dimensions on plot plan or foundation plan

A. Measure

1. Very accurately, lengths and depths
2. With steel measuring tape
3. Along main building lines (two), opposite and parallel
4. From main building corners
5. Dimension as per plot/foundation plan
6. To building insets (subsidiary building line)

B. Mark



1. Points measured on main building lines
2. With 2" x 2" x 12" long stake
   a. Set vertically in ground
   b. Approximately 10" deep
3. With 8d finish nail
   a. Set vertically in top of stake
   b. On exact point measured and building line
   c. With head of nail exposed 1/2"

Note: Lines stretched between points located on opposite main building lines form, in part, subsidiary building lines. The intersection of a subsidiary building line and a main building line will form an outside building corner (see plans)

14. Select Batterboard Material

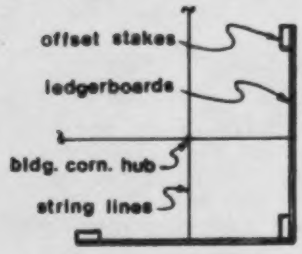
1. Corner batterboards (each corner)
   a. (2) 1" x 6" x 8'-0 lg. ledger boards
   b. (3) 2" x 4" x 3'-0 lg. offset stakes
   c. 6d common nails as required
2. Straight batterboards (end of subsidiary building lines)
   a. (1) 1" x 6" x 8'-0 long ledger board
   b. (2) 2" x 4" x 3'-0 long offset stake
   c. 6d common nails as required

Note: All material to be good quality and straight

15. Position Ledger Boards

1. Flat on ground
2. 4'-0 outside of building lines (or as required to clear any foundation excavation)
3. Parallel to building lines
   a. To form a corner outside the building corner, or ...
   b. To be approximately centered on subsidiary building lines

16. Set Offset Stakes



Corner Batterboard

1. In vertical position
2. Side of stakes flush with inside of ledger boards
   a. One stake in corner flush with both ledgers
   b. One stake at/or near each end of ledger boards
3. Drive stakes vertically into ground
4. Approximately 15" deep or until firm in ground

17. Mark Offset Stakes

1. To gage erection of ledger boards
2. At top of concrete elevation

A. Set Up And Level Transit

1. Within easy sight of TBM
2. Within easy view of all offset stakes

B. Determine H.I.

1. Hold level rod vertically on TBM
2. Shoot level rod with transit telescope
3. Read level rod to nearest hundredth-of-an-inch at telescope horizontal cross-hair

	4. Add reading to TBM elevation Example: 317.85' TBM Elevation + 5.32' Rod Reading 323.17' HI
C. Calculate Rod Reading	1. For "top of concrete" elevation 2. Subtract top of concrete elevation 3. From height of instrument Example: 323.17' HI El. 320. 0' T.O.C. El. 3.17' Rod Reading
D. Position Rod	1. At each offset stake 2. One-at-a-time 3. Adjacent to stake 4. In vertical position
E. Read Rod	1. With transit telescope 2. While signaling rodman to raise/lower level rod 3. Until levelman obtains 3.17' reading on rod
F. Mark Offset Stakes	1. At base of level rod 2. With a horizontal line 3. On side of stake 4. Very accurately Note: This line marks "top of concrete" elevation
18. Erect Batterboard Ledgers	1. One-at-a-time 2. Very carefully
A. Position Ledger Board	1. On outside of offset stakes (2) 2. Top edge of board on "T.O.C." marks on side of stakes 3. Ends of boards flush at corner stake
B. Mark For Nailing	1. While ledger board is in position 2. Two nails each end a. Approximately 1" from each edge b. Approximately centered with stake
C. Start Nails	1. Lay ledger board flat on ground 2. Set 6d nails vertically at points marked 3. Drive nails almost through ledger board
D. Tack Ledger Board In Place	1. Reposition ledger board on offset stakes 2. Back (buck) offset stake with sledge hammer 3. Set one nail in each stake 4. Approximately 1/2" deep

Check Point:	Check following:
	1. Batterboards to be level - set builder's level...
	   a. Along top edge of ledgers
	   b. Diagonally across corner ledgers
	2. Batterboards set to "top of concrete" elevation
	   a. Set level rod on top center of ledger
	   b. Read rod with transit telescope

E. Nail Ledger Board In Place	1. Back (buck) offset stake with sledge hammer 2. Drive nails to set head flush 3. Repeat steps #18-A, B, C, D until all batterboards are erected
Check Point:	Check all batterboards to be rigid and sturdy construction
19. Mark Building Lines	1. On ledger boards 2. One-at-a-time 3. Using mason's line and plumb bobs (2)
A. Stretch Mason's Line	1. Over opposing ledger boards 2. On opposite sides of building 3. Aligned by eye 4. With building line and corner hubs

B. Suspend Plumb Bobs	1. From mason's line
	   a. Over building corner hubs
	   b. Near each end of mason's line (about 4'-0)
	2. With fine, strong, string
	   a. Tie in slip knot
	   b. To allow movement along line
	3. To clear nail in top of hub stake approximately 1/4"

C. Align Mason's Line	1. With building line
	2. Using plumb bobs and string line
	   a. Adjust alternately
	   b. Plumb bobs along length of line
	   c. String line laterally (side to side)
	3. To center precisely over building corner hubs

D. Mark Building Line	1. On top edge of ledger board 2. With a sharp pencil 3. Using mason's line as guide Note: Mark both ledger boards (opposite ends of string line) on same side of string

4. Cut shallow saw kerf
    - a. On string side of line
    - b. On back edge of ledger board
    - c. At 45° angle
    - d. Approximately 1/4" deep
    - e. With a fine tooth cross-cut saw
5. Set 4d finish nail
    - a. Firmly (approximately 3/4" deep) on back side of ledger board
    - b. About 1" below saw kerf
    - c. While backing (bucking) ledger board with a sledge hammer

Check Point: Double check all batterboards:
- a. Construction to be sturdy; rigid
- b. Set well outside excavation lines
- c. Ledgerboards to be level; all at correct elevation (T. O. C.)
- d. Ledger lines precise; exacting

III. APPLICATION (PRACTICE BY LEARNER UNDER CLOSE SUPERVISION)

Students become familiar with job and tasks sequence

Students practice:

- a. Setting up and leveling instrument
- b. Shooting a line with a transit
- c. Making precision measurements with steel tape
- d. Shooting and reading a level rod
- e. Constructing batterboards properly to a given elevation
- f. Marking batterboard ledgers precisely

IV. VERIFICATION AND/OR EVALUATION (CHECK ON STUDENT'S ABILITY)

Performance test by students

Lay out and mark building outline on site according to builder's plans

Check building size, squareness, position on lot/site

Erect required batterboards to a given elevation

Transfer building lines to batterboard ledgers precisely

V. SUMMARY (TELL THE STEPS ON PROCEDURE AS TO WHAT, HOW, AND WHY. REVIEW CHECKING STANDARDS. THIS SUMMARY MAY BE GIVEN AT ANY PLACE IN THE LESSON THE TEACHER FEELS WILL BE PROFITABLE TO THE STUDENTS.)

Study builder's plans and dimensions. Determine best procedure to locate and lay out building outline on site.

Locate and lay out building lines (corners) precisely using hub stakes with 8d nails to locate exact corners.

Check building outline for dimensions, square, and location. Check easements and restrictions.

Erect batterboards as required.

- a. "L-shaped", at outside building corners
- b. "Straight", opposite side of inset building lines
- c. Well outside construction area (approx. 4'-0 on slab foundations)
- d. Sturdy, rigid construction
- e. Ledgerboards level; at given elevation

Transfer building lines to ledgerboards

- a. Using mason's line and plumb bobs (2)
- b. Stretch line across ledger boards aligned with corner hubs (2)
- c. Suspend plumb bob over each corner hub
- d. Align mason's line with building line exactly by alternately adjusting position on string line and plumb bobs until plumb bobs suspend directly over nail in corner hub
- e. Mark line on ledger board each end using mason's line as a guide

SUGGESTED READING FOR THE STUDENT:

Modern Carpentry, Unit 6
Fundamentals of Carpentry, Chapter 3

The Next Lesson Is: II-A-6(S), "Prepare Sub-Base For Slab And Beam Foundation"

JOB SHEET
IN
BUILDING SITE PREPARATION

II-A-5(J)

NAME OF JOB:	Set Corner Hubs And Erect Batter Boards	
DRAWINGS:	Blueprint plot plan, floor plan, foundation plan and details	
MATERIALS:	2" x 2" x 12" lg. stakes, 8d finish nails, 2" x 4" x 3'-0 lg. stakes, 8d common nails, 1" x 6" x 8'-0 lg. lumber, nylon cord	
TOOLS AND EQUIPMENT:	Builder's level, lining rod, level, tripod, 100' steel tape measure, claw hammer, plumb bob, 3 lb. engineer's hammer, hand saw	
GENERAL INSTRUCTIONS:	Layout of the building and setting of building corner hubs may be accomplished similar to previous lesson II-A-2(S) except with more accuracy. Use the builder's level to turn angles and shoot lines with extreme accuracy and be exact with all measurements. Once the building lines are established and corner hubs firmly set in the ground, the builder must erect batter boards and transfer the building lines to these batter boards in the form of a ledger with equal precision, as all ground marks are quickly lost when excavation and form construction commence. Batter boards are erected well outside the building lines so that they will not be disturbed by excavation and construction. Properly constructed, batter boards will serve a two-fold purpose: (1) horizontal building control; and (2) vertical building control.	
PROCEDURE AND/OR TASK:	II-A-5(TS)	Set Corner Hubs And Mark Subsidiary Building Corners
	II-A-5a(TS)	Erect Batter Boards And Stretch String Lines

TASK: Set Corner Hubs And Mark Subsidiary Building Corners

JOB: Set Corner Hubs And Erect Batter Boards

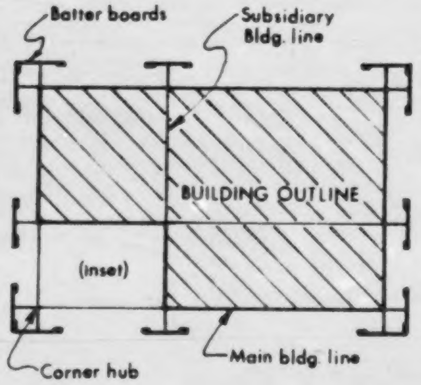
TRADE: Building Trades

TOOLS AND MATERIALS: Builder's level, 100' steel tape measure, nylon cord, tripod, 3 lb. engineer's hammer, 8d finish nails, plumb bob, lining rod, 2" x 2" x 12" lg. stakes

TASK BREAKDOWN:

STEPS	KEY POINTS
1. Mark Property Front Boundary	1. Similar as in previous job II-A-2(J) 2. With nylon cord stretched taut 3. From property front corner to property front corner
CHECK POINTS:	Visually inspect line to be straight
2. Measure Building Front Offset, Building Front	1. From property corner as indicated on plot plan 2. Along property front boundary line 3. Very accurately!
3. Mark Exact Points	1. With 2" x 2" x 12" lg. stake set vertically in ground on line at point measured 2. With 8d finish nail in top of stake at exact point
4. Set Up Level Instrument Over Each Point	1. One-at-a-time 2. Set up; level; orient telescope with property front boundary 3. Similar as in job II-A-1(J)
5. Turn 90° Angle And Shoot Depth Offset Lines	1. Into property interior 2. Using lining rod to shoot lines 3. Mark exact point of alignment similar as in step #3 above 4. Mark depth offset lines with nylon cord stretched taut similar as in step #1 above
CHECK POINTS:	Nylon string marking depth offset line to align with vertical cross-hair of telescope
6. Measure And Mark Depth Offset, Building Depth	1. From property front 2. On each depth offset line

STEPS	KEY POINTS
	3. Similar as in steps #2 and #3 above Note: 2" x 2" x 12" lg. stakes with 8d finish nail in top marking building depth offsets and building depth each line are the building corner hubs
CHECK POINTS:	Check the big square/rectangle: A. Overall length, depth dimensions B. Diagonal corners equal distance
7. Measure And Mark Subsidiary Building Corners	1. From main building corner hubs 2. Along main building lines 3. As per floor plan dimensions 4. Mark point similar as in step #3 above
8. Measure And Mark Opposite Building Line	1. Side/end opposite and parallel 2. With identical dimension 3. Mark in a like manner


Batter boards
Subsidiary Bldg. line
BUILDING OUTLINE
(inset)
Corner hub
Main bldg. line

TASK SHEET

II-A-5a(TS)

TASK: Erect Batter Boards And Stretch String Lines

JOB: Set Corner Hubs And Erect Batter Boards

TRADE: Building Trades

TOOLS AND MATERIALS: Builder's level, claw hammer, 2" x 4" x 3'-0 lg. offset stakes, tripod, hand saw, 1" x 6" x 8'-0 lg. ledger boards, level rod, 6 or 8d common nails, carpenter's level, 3 lb. engineer's hammer

TASK BREAKDOWN:

STEPS	KEY POINTS
1. Select Batter Board Material	1. Ledger boards (1" x 6" x 8'-0 lg.) a. (2) each corner hub b. (1) each subsidiary corner marker 2. Offset stakes (2" x 4" x 3'-0 lg.) a. (3) each corner hub b. (2) each subsidiary corner marker 3. All material to be straight, good quality
2. Position Ledger Boards	1. Flat on ground 2. 4'-0 outside of building lines ...or as required to clear any foundation excavation 3. Parallel to building lines to form corners outside of corner hubs; to be approximately centered on subsidiary building marks
3. Set Offset Stakes	1. In vertical position 2. Side of stakes flush with inside of ledgers a. One stake in corner flush with both ledger boards b. One stake at/or near each end of ledgers 3. Drive stakes vertically into ground approximately 15" deep or until firm
4. Mark T.O.C. Elevation On Corner Offset Stakes	1. Set up and level instrument similar as in previous tasks a. Within easy sight distance of TBM b. Within easy sight of all corner hubs 2. Shoot level rod set vertcial on TBM

STEPS	KEY POINTS
	and calculate H. I.; record
	3. Determine difference in H. I. and T. O. C. H. I. el. – T. O. C. el = difference; record
	4. Set level rod vertically adjacent to corner offset stake one-at-a-time and read rod
	5. Subtract "difference" from rod reading and place horizontal mark on corner offset stake
5. Erect Batter Boards	1. One-at-a-time
	2. Start nails (6 or 8d common) in batter board
	a. (2) each end, (1) each side
	b. In line with center of offset stakes
	3. Position batter board
	a. Top edge to horizontal mark
	b. Top edge level – use carpenter's level
	c. Side flush with stakes
	4. Temporarily set nails
	a. One each end
	b. While backing stake
CHECK POINTS:	Check board level and elevation
	a. Place level rod on board near one end
	b. Shoot rod held in vertical position
	c. Rod should read "difference" calculated in step #3, key point #4 above
	d. Repeat at opposite end of board – readings should be the same
	5. Set all nails while backing the stakes
6. Stretch String Lines	1. One-at-a-time
	2. Taut over opposing ledger boards
	3. Aligned directly over building line
	4. With plumb bobs (2) suspended directly over each corner hub
7. Mark Ledger (Building Line)	1. On top of ledger board
	2. With a fine/sharp marker
	3. Using string line stretched taut as a guide
	Note: Keep marks of opposing ledger boards on the same side of the string line

STEPS	KEY POINTS
	4. Remove string and make a 45° saw kerf on back, top side of ledger halfway through ledger thickness
	5. Set a tie-nail on back side of ledger 2" below the saw kerf
CHECK POINTS:	Check Job Accuracy: a. Set (stretch) all string lines b. Suspend plumb bob at each intersection of string lines, one-at-a-time c. Plumb bob should suspend directly over a corner hub

INSTRUCTOR'S PLAN
INFORMATIONAL LESSON

SUBJECT:	Soil Preparation and Special Excavation
AIM:	The student will be able to classify local soils according to their texture and structure. The student will further be able to explain the reasons for conditioning soil in a particular way prior to laying a building foundation over it.
TEACHING AIDS:	Information Sheets BT-II-1(IS) and BT-II-1a(IS), Chalkboard
MATERIALS:	Chalk, soil samples (obtained locally)
REFERENCES:	Watson, Don A., Construction Materials and Processes, McGraw-Hill Book Co., 1221 Avenue of Americas, New York, N.Y. 10010 Dagostino, Frank R., Methods and Materials of Commercial Construction, Reston Publishing Company, Inc. Reston, Virginia 22090
PREREQUISITE EXPERIENCE OF THE LEARNER:	The student must have met all course prerequisites as set forth in state and local school policies. The student must further display positive attitudes and a sincere interest in learning the building trades.

I. PREPARATION (OF THE LEARNER - MOTIVATION)

Following the removal of unwanted objects and growth and the stripping of top soil, is the task of preparing the earth to receive the building foundation. This is generally referred to as excavation and earthwork.

Once excavation begins, the earth is disturbed and tends to assume a larger volume. As loosened soil expands it assumes a larger volume which is referred to as swell. Swell may also be caused by the presence of an excess of water; therefore, this condition must be counteracted before construction begins or the building foundation will crack due to subsidence (the natural settling of the soil under the load of the building's weight) and cause serious damage to the building structure.

This lesson discusses the action of soils and means of achieving a soil density to carry specified loads without undue settlement.

II. PRESENTATION (OF THE INFORMATION)

INSTRUCTIONAL TOPICS TEACHING POINTS	THINGS FOR STUDENTS TO DO THINGS FOR INSTRUCTOR TO DO OR SAY
A. Nature of Soils	1. Soils are a result of mechanical and chemical weathering of rock

2. Soils are found in a wide range of particle size, shape, and composition
3. Soils' consistency range from a solid to an almost liquid state
4. Soils differ from other natural materials in that they can be modified to conform to certain desired characteristics

1. Solid Soils

1. Are comprised of massive rock foundations
2. Have constant density when undisturbed
3. Are little affected by moisture, temperature, and vibration when undisturbed
4. Characteristics may be altered by excavation, moving water, extreme temperature changes

2. Plastic/Viscous and Fluid Soils

1. Are susceptible to change in shape
2. Resist change in volume when contained
3. Are affected by moisture content, external pressure

B. Behavior of Soils (Plastic, Viscous and Fluid)

1. Tend to change in volume as its moisture content changes (expand and contract)
2. Tends to move under pressure (is compressible)
    - a. Each soil will vary in amount of force required to start it moving
    - b. A plastic soil will cease movement when the force is removed
    - c. A viscous or fluid soil will continue to move until counteracted by an opposing force
3. Will react in three different ways when a load is applied:
    - a. Elastic compression; as a rubber mat when it is stepped on
    - b. Consolidation of soil; as water and air are squeezed out (compacted)
    - c. Plastic creep; flow of soil particles

C. Soil Water

Note: Its presence may be in several forms

1. Gravitational water - also called "water table" or ground water
    - a. Water that flows through the soil
    - b. Can be removed by pumping
2. Film water
    - a. Surrounds individual soil grains

- b. Can be removed by drying
3. Absorbed / capillary water
    - a. Absorbed in minute pores and/or clings to individual soil particles
    - b. Acts to bind soil particles together

D. Capillary Rise

1. Water holds an affinity (attraction) for certain fine grained soils
2. Water is absorbed (drawn up) through these soils
3. The distance of the draw or rise depends on:
    - a. The particle size
    - b. The compactness or contact between the particles
4. Capillary rise in fine grained sand is considerable

E. Optimum Moisture

1. Is a particular moisture content for each type soil which permits that soil's greatest compaction
    - a. A water film around individual soil particles acts as a lubricant during compaction permitting a closer fit
    - b. Too much water creates fluidity; loosens soil
2. This moisture content is called soil's "optimum moisture content"; is about 12%
3. This compaction is called soil's density

F. Soil Density

1. Is the weight per cubic foot of compacted soil
2. Varies with type of soil
3. Depends on soil's:
    - a. Ability to compact; soil's particle size and shape
    - b. Optimum moisture content

G. Swell and Shrinkage

1. Swell is caused by the soil being disturbed (loosened) either by natural causes or man made

    Example: Earth being loosened or cut by excavation equipment. Earth loosened by an excessive increase in moisture content
2. Swell is referred to as "heave"
3. Shrinkage is called "settlement"
4. Soil settles for two reasons:
    - a. Air and water are expelled through compression

b. Soil is forced outside the site into the surrounding areas

H. Soil Stabilization

1. Is intended so that most heave and/or settlement takes place before construction
2. Is accomplished by
   a. Controlling moisture content
   b. Compaction

Passout: II-A-7(IS)

Note: Discuss information sheet with class

1. Soil Modification

1. Includes loosening of soil and turning to allow the escape of moisture by evaporation
2. Often requires mixing soil with lime, cement, other more stable soils to increase desired characteristics

2. Dewatering

1. Is the control of the flow of ground water
2. By means of open joist drain tiles
   a. Tiles placed just above footings
   b. Leads free water away from bearing stratum below footings
3. Used mostly in construction where the foundation is carried below groundwater level; basement construction

3. Compaction

1. Purposes:
   a. To produce volumetric stability in the soil which will prevent excessive settlement
   b. Reduce permeability of soil which will reduce the amount liquids which can pass through it
2. Most common methods are:
   a. Sheep's - foot rollers
   b. Flat rollers
   c. Pneumatic tampers
3. Is required to provide a firm base that will carry a specified load with minimum settlement

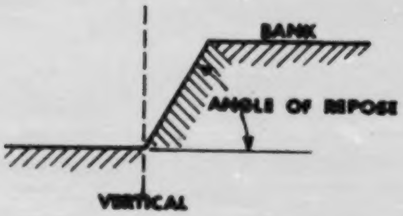
I. Special Excavation

1. Includes work which requires special equipment, work in small areas, and work difficult to accomplish

   Examples: 1. Small trenches
   2. Footing holes
2. All handwork is classified special excavation

3. Handwork includes:
   a. Hand digging to specified width and depth of excavation
   b. Sloping the banks (sides of excavation) where necessary
   c. Removal of vegetable, foreign matter in excavation
   d. Tamping to a relatively flat, smooth surface

1. Angle of Repose



1. In earth work, is the angle with a horizontal plane or surface at which an earthen bank will not collapse or cave-in
   Note: Illustrate on chalkboard
2. Varies with type soil and moisture content

Material Type	Wet	Moist	Dry
Gravel	15-25°	20-30°	25-40°
Clay	15-25°	25-40°	40-60°
Sand	20-35°	35-50°	25-40°

2. Working Clearances

1. Are excavated areas outside the limits of the foundation forms
2. Should be adhered to when workers must enter the excavated area in order to set foundation forms
3. Are recommended to be 2' - 0" when excavation is other than minimal depth

III. APPLICATION (DRILL, ILLUSTRATIONS, ANALOGIES, ORAL QUESTIONS OR ASSIGNMENTS, MAKING INVESTIGATIONS OR EXPERIMENTS, NOTE TAKING, MAKING SKETCHES, PARTICIPATING IN DISCUSSION.)

- * Passout: BT-II-1a(IS) "Texture and Structure of Soils"
- * Discuss passout with class
- * Students obtain soil samples from local area
- * Class identify (classify) soil samples according to texture and structure
- * Class discuss load bearing qualities of soil samples

IV. VERIFICATION AND/OR EVALUATION (FINAL CHECK ON STUDENTS' COMPREHENSION OF MATERIALS PRESENTED.)

Simple Recall

1. Soils are the result of mechanical and chemical weathering of _____ .	rock
2. Soils are found in a wide range of particle size, shape, and _____ .	composition

IV. VERIFICATION (CON'T.)

3. _____ soils have fairly constant density when undisturbed.	solid
4. Plastic and viscous soils tend to change in volume as their _____ changes.	moisture content
5. Gravitational water, water which flows through the soil, is also called "water table" or _____ .	ground water
6. The process of soil water being drawn up above the water table by certain soils is called _____ .	capillary rise
7. The particular moisture content which will permit a soil's greatest compaction is referred to as the soil's _____ moisture content.	optimum
8. Soil's _____ is the weight per cubic foot of compacted soil	density
9. The expansion (swell) and contraction (shrinkage) of soils is referred to as "heave" and _____ .	settlement
10. In earth work, the angle with a horizontal plane at which an earthen bank is safe from collapse is called "the angle of _____ .	repose

V. SUMMARY (GIVE A BRIEF ACCOUNT OF EACH TOPIC REEMPHASIZING THE IMPORTANT POINTS. THIS SUMMARY MAY BE GIVEN AT ANY PLACE IN THE LESSON THE TEACHER FEELS WILL BE PROFITABLE TO THE STUDENT.)

* Soils are a result of mechanical and chemical weathering of rock and are found in a wide range of particle size, shape, and composition.

* Soils may be separated in two broad categories: (1) solid soils; (2) plastic, viscous and fluid soils.

* Solid soils are comprised of massive rock formations which have a constant density when undisturbed, but plastic and viscous soils tend to change in volume and shape when influenced by moisture and/or pressure.

* Most soils can be modified to conform to certain desired characteristics; improve their load bearing qualities. This is accomplished through soil modification; dewatering, and compaction.

* Soil modification includes mixing soil with various materials to provide a denser subbase. Dewatering is to control the flow of subterranean water by means of open-joist drain tiles around to lead away free water before it can reach the bearing stratum. And compaction of soil to achieve a soil density which will carry the specified loads.

* **The solution to foundation problems lies in the hands of the architect but the remedy must be carried out by the man in the field; therefore, the more he understands why he is doing something, the easier it is for him to do it.**

SUGGESTED READING FOR THE STUDENT:

Ref. #1, Modern Carpentry, pp. 89-110
Ref. #2, Fundamentals of Carpentry, pp. 50-104

The Next Lesson Is: II-B-1(I), "Concrete Forms"

INFORMATION SHEET
ON
BEARING CAPACITIES OF SOILS

SUBJECT: Bearing Capacities of Soils

INTRODUCTORY INFORMATION:

Building codes usually specify allowable bearing pressures for various types of soil. These tables seldom take into consideration the presence of moisture or the compressibility of the soil.

The table below expresses the allowable pressure in terms of pounds that can be supported by one square foot of soil without excess settlement or rupture of the foundation. It may be used for light structures, such as one-and two-story frame residences, or small commercial buildings. However, for larger projects, the soil should be investigated and appropriate tests made.

GENERAL INFORMATION:

ALLOWABLE SOIL PRESSURE PER SQUARE FOOT OF FOOTING BELOW ADJACENT VIRGIN GROUND

MATERIAL	MINIMUM DEPTH	VALUE LB/SQ FT	VALUE EACH FOOT ADDITIONAL DEPTH	MAXIMUM VALUE
Rock	0'	20% of ultimate crushing strength	0	20% of ultimate crushing strength
Compact coarse sand	1'	1500*	300*	8000
Compact fine sand	1'	1000*	200*	8000
Loose sand	2'	500*	100*	3000
Hard clay or sandy clay	2'	4000	800	8000
Medium-stiff clay or sandy clay	1'	2000	200	6000
Expansive soils	1'-6"	1000☆	50	–
Soft sandy clay or clay	2'	1000	50	2000
Compact inorganic sand-and-silt mixtures	1'	1000	200	4000
Loose inorganic sand-and-silt mixtures	2'	1000	200	1000
Loose organic sand-and-silt mixtures and muck or bay mud	0'	0	0	0

*These values are for footings 1 ft in width and may be increased in direct proportion to the width of the footing, to a maximum of three times the designated value.

☆For depths greater than 8 ft use values given for clay of comparable consistency.

INFORMATION SHEET
ON
TEXTURE AND STRUCTURE OF SOILS

II-A-7a(IS)
(p. 1 of 2)

SUBJECT: Classification of Soils by Texture and Structure

INTRODUCTORY INFORMATION:

Soils are the product of mechanical and chemical weathering of rock. Soils are found in a wide range of particle size, shape, and composition. Of the several methods of classifying soils, the one most used by engineers in the field and referred to by building codes is the classification of soils by texture and structure on the basis of visual inspection.

GENERAL INFORMATION:

This table is similar to that found in several building codes.

Texture and Structure of Soils

TYPE OF SOIL	DESCRIPTION
Compact Coarse Sand	Consists of coarse particles, 1/4 in. or less in diameter. Predominately quartz with no binder compacted by the weight of overburden or weather. The grains are generally spherical or angular depending on extent of weathering and decomposition. Little affected by water or frost as the particles fit closely together.
Compact Fine Sand	Wet or dry, when confined, will bear heavy loads. Water will make fine sand flow more readily than coarse sand. Fine sand has a lower bearing value than coarse sand as fine particles can be rearranged and squeezed together under loads.
Loose Sand	Either fine or coarse will flow under the action of water. Finer particles move more readily leaving voids in the soil. Loose sands tend to flow under load unless confined.
Clay	Consists mainly of mineral feldspar and various impurities. Particles are microscopic needle or disc shaped grains whose surface areas are large in proportion to their volume. Compact dry clay will support heavy loads. Wet clay becomes slippery and unstable. Clay expands and contracts in direct relation to its moisture content so that its volume varies from 10 to 20 percent.

Silt	Is a very fine, soft material deposited in the bottoms of rivers and lakes and composed of the finer particles of mineral and inorganic sand. Loose silts are unsuitable for bearing materials.
Sandy Clay	Is a sandy soil with enough clay to act as a binder. It exhibits many of the properties of sandy soils without the movement of loose sand and without the slipping qualities of clay.
Loam	A mixture of relatively even proportions of sand, silt, and clay usually with some inorganic matter. Loam is quite friable (easily crumbled or pulverized).
Sandy Loam	Basically a sandy soil with enough clay and silt to render it cohesive (make it stick together).
Silt Loam	A soil having a moderate amount of clay and sand, in which over 50 percent of the sand is extremely fine particles.
Clay Loam	A mixture of sand clay and silt having a large percentage of clay.
Hardpan	Refers to a highly consolidated sedimentary formation composed of clay, sand, gravel, and/or boulders. Term denotes a degree of hardness rather than a particular soil composition.
Shale	An intermediate stage between clay and slate, highly consolidated by pressure. Shale may be reduced to a plastic state by moderate grinding and the addition of water.

INSTRUCTOR'S PLAN
MANIPULATIVE LESSON

II-A-6(S)

TASK: Prepare Sub-base For Slab And Beam Foundation

AIM: The student will be able to differentiate between quality and poor foundation soils and take appropriate and adequate action to prepare the foundation soil to receive the building foundations according to the builder's plans and specifications.

TOOLS AND EQUIPMENT: Steel measuring tapes, shovels (sharp shooters and square point shovels), picks, wheel barrows, tampers (hand and pneumatic), engineer's hammer or light sledge hammer

MATERIALS: Stringlines, surveyor's laths, backfill (as specified and required)

TEACHING AIDS: Builders plans and specifications, soil sample test results, pencils, notepad

REFERENCES:
Modern Carpentry, Unit 6
Methods And Materials of Commercial Construction, pp. 27-43
Concrete Form Construction, Units 1, 9, 10

PREREQUISITE EXPERIENCE OF THE LEARNER: The student must have successfully completed previous lessons I-B-2(I) Shop Rules, I-C-1(I) Shop Organization, I-D-1(I) Personal And Shop Safety, II-B-1(I) Soil Preparation

CHECKING STANDARDS:

1. Willingness to perform less desirable jobs and tasks in carpentry
2. Ability to work well with others
3. Ability to work as a member of a team
4. Safe, efficient use of time; tools
5. Follows acceptable building methods and procedures

I. PREPARATION (OF THE LEARNER - MOTIVATION)

One of the most important factors in determining foundation requirements for a home or other structure is the soil; the ground on which the building is erected. There are many different types of soil; some totally unsuited to support a building; others may be suitable but require certain precautions, or modifications, before the building foundations are erected.

When earth is disturbed, loosened by grading and/or excavation, it tends to assume a larger volume. This is referred to as swell. Swell may also be caused by natural means such as an excess of ground water and certain soils' affinity for water. These conditions will cause the land to "heave" and "subside" (swell and shrink). Excessive heave and subsidence can cause many building problems if neglected; the foundation may settle unevenly, slab foundations may crack, plumbing and sewer lines may leak, masonry walls and drywalls may crack and separate.

I. PREPARATION (CON'T.)

When a building or dwelling is designed for a particular site, the architect should have already obtained a soil analysis and have resolved any problem pertaining to its foundations. All the builder must do is follow the architect's blueprints and specifications. However, quite often an individual will obtain a set of standard blueprints, purchase a lot or site of his choosing, and approach a builder to construct that building on that site having no knowledge of the soil in the area. In such cases the builder should obtain a soil analysis and recommendations for soil preparation and modification to support given building loads in that area, and wisely, follow those recommendations.

Soil modification is of two types: (1) soil stablization, which is the introduction, mixing, and compaction of other soils and minerals to improve native soils' load bearing qualities; and (2) moisture control, which is accomplished primarily through moisture barriers, and in extremely moist conditions, adequate drainage systems to carry off excess moisture. Although this may be one of the less desirable jobs within the building trades, it is none the less important. Properly prepared earthwork goes far to insure a sound and lasting foundation.

II. PRESENTATION (OF THE SKILLS)

STEPS	KEY POINTS (THINGS TO REMEMBER TO DO OR SAY)
1. Study Foundation Plans, Details, Specifications	1. To become familiar with: a. Type foundation specified b. Foundation details c. Underground plumbing and piping details d. Foundation sub-surface specifications
	2. To determine: a. Thickness of foundation slab b. Thickness of compactable backfill c. Depth; width of foundation beams d. Angle of repose of native soil e. Areas and locations to be excavated f. Best procedure for excavation and soil preparation
2. Level And Smooth Sub-grade	1. To accommodate form work 2. To allow sufficient cushion material depth (compactable backfill)
A. Stretch String Lines	1. On batterboards 2. To locate building lines
B. Adjust Sub-grade Perimeter	1. With picks, shovels, rakes 2. To be level and smooth 3. In the area below the string line 4. To a uniform distance below the strings

5. As calculated/indicated from blueprints
   Example:

```
T.O.C. EL.  320.0'  (stringline)
          -    .5'  concrete slab
            319.5'
          -    .5'  compactable backfill
            319.0'
320.0'- 319.0'= 1.0' stringline to subgrade
```

C. Set Grade Stakes
1. Of $\frac{1}{2}$" x 2" x 18" long laths vertically in ground
2. On two opposite building lines
3. On 10'-0 intervals from one end
4. With tops of laths level with batterboard string lines

D. Mark Grade Story Poles
1. On $\frac{1}{2}$" x 2" laths
2. Data obtained from plans and details
   a. Slab thickness
   b. Cushion thickness (compactable backfill)
3. With horizontal penciled line
4. Measured from batterboard string lines

E. Stretch String Lines
1. Between grade stakes
2. On opposite building lines
3. At sub-grade story marks

F. Adjust Sub-grade
1. With hand tools
2. Over entire foundation area
3. Use string lines as guide
4. Cut high places
   a. Loosen high sub-grade
   b. Use picks, shovels, hoes
5. Fill low places
   a. With loose sub-grade from cuts
   b. Using shovels, rakes
6. Until sub-grade is level and at correct elevation

G. Remove Debris
1. From foundation area by hand
   a. All roots, sticks, large stones, foreign matter
   b. As sub-grade is loosened; adjusted
2. Dispose of debris as allowed by specifications, building codes, city ordinances

H. Remove Excess Sub-grade
1. From foundation area
2. With wheelbarrow
3. Re-distribute over job site premises

	Note: Spread in thin even sheets. Do not build up or block drains
I. Add Stabilizing And Drying Agents	1. As required a. To aid in drying sub-grade b. To aid in stabilizing sub-grade 2. Evenly over foundation area 3. Mix lightly with loose sub-grade 4. Use rakes, hoes to mix and level Note: Wear appropriate safety apparel if additives are caustic. This may include respirator, goggles, gloves, boots
J. Compact Sub-grade	1. Over entire foundation area 2. Use hand tampers, pneumatic tampers 3. Maintain uniformity and level Note: Steps 2F thru 2J may have to be repeated in whole or any part to obtain a uniform level of sub-grade
3. Add Foundation Base Or Cushion Material	1. As required in building specifications 2. Thickness as per foundation details 3. Over entire foundation area
A. Take Soil Sample	1. From material stock pile 2. Clean sample of vegetation; debris 3. Place loose soil in cylindrical container
B. Check Moisture Content	1. To be ten to twelve percent 2. For optimum moisture content and compaction 3. Squeeze handful of loose soil a. Should feel slightly damp b. Should stick together in cake form c. Should not stick to hand excessively leaving sticky or muddy residue
C. Compute Soil Compaction Factor	1. Fill cylindrical container a. Level full b. Loose material 2. Compact material a. By vibration b. By hand ram 3. Measure height of cylinder (example: 12") 4. Measure height of compacted soil (example: 10")

5. Determine soil compaction factor
   a. Divide volume height of loose soil
   b. By volume height of compacted soil
   Example:
   12" ÷ 10" = 1.2, compaction factor

D. Calculate Required Backfill

1. For slab cushion
2. From blueprint plans and details
3. Compute: $\frac{\text{area x volume x compaction factor}}{27}$
   Example:

48' length
× 25' width
1344 sq. ft. (area)
× .5' volume
672 cu. ft.
× 1.2 compaction factor

$$\div \frac{806.4 \text{ cu. ft.}}{27 \text{ cu. ft.}} = 29.86 \text{ cu. yd.}$$

Note: Remove sub-grade string lines before positioning cushion material

E. Position Material

1. In small piles
2. Uniformly spaced
3. Over entire foundation area
4. Use wheelbarrows; other conveyance

F. Disperse Material

1. Evenly over entire foundation area
2. Using rakes and shovels
3. Similar as with sub-grade, step #2F, 2G

G. Compact Material

1. Over entire foundation area
2. Use hand tampers; pneumatic tampers

Check Point:

1. Stretch string lines between grade stakes
2. At story mark "top of compactable fill"
3. Visually check level and elevation
   Note: Repeat steps #3F, G, H, all or any part until required level and elevation is obtained

Note: Excavation for beams in monolithic slab and beam foundations is generally reserved until after foundations forms are set. See lesson II-B-1(S) for slab and beam form construction at this point

4. Lay Out Excavation

1. For foundation beams, walls, footings
2. For underground plumbing; utilities
3. On building site as required
   a. Very accurately
   b. Use steel measuring tapes

4. Measure from building corners to locate:
    a. Inside beams
    b. Inside wall footings
5. According to blueprint foundation plans
6. Use building lines as a guide:
    a. For tape measurements
    b. For building perimeter beams, walls, footings
7. Measure beams, wall footings width
    a. As per foundation sections and details
    b. Include sufficient work space where forms must be erected
8. Set stakes and string lines
    a. For excavation guides
    b. Where necessary

Check Point: Double check excavation layout and dimensions before any excavation commences

5. Excavate

1. For foundation beams, walls, footings as called for in plans, specifications
2. With trenching machine where feasible
    a. Consult with machine operator before excavation
    b. Assist operator upon request
    c. Oversee and advise operator on excavation
3. With hand tools where required
    a. Trim walls; square corners
    b. Clean debris from trenches
    c. Level and compact trench bottoms
    d. All special excavation

    Note: Slab and beam foundations use trench walls for concrete forms below grade. Do not overcut width, depth of beam trenches
4. Apply proper technique, safety in use of hand digging tools
5. Check width, depth of excavation regularly
    a. While digging
    b. With a yardstick or folding rule
    c. Against building string line (T.O.C.)
6. Store earth removed from excavation outside of building lines
    a. In an area that will not interfere with future construction

II. PRESENTATION (CON'T.)

b. For removal/reuse some later date

Note: Refer to Plumbing Basic Course Outline, pp. 42-43, Major Block III, Minor Block B for underground plumbing trenches, location, installation of plumbing, backfill and compaction.

III. APPLICATION (PRACTICE BY LEARNER UNDER CLOSE SUPERVISION)

1. Students become familiar with job, tasks, steps and keypoints, from job, task sheets
2. Students preview blueprints, specifications (under instructor's supervision) to determine:
   a. Key dimensions, locations for excavation
   b. Specifications for soil sub-grade preparation
   c. Work procedures and sequence
   d. Team assignments and student responsibilities
   e. Work safety procedure
3. Students take soil samples:
   a. Hand test for optimum moisture content
   b. Compute soil compaction factor
   c. Calculate required compactable backfill for sub-grade of hypothetical building foundation

IV. VERIFICATION AND/OR EVALUATION (CHECK ON STUDENT'S ABILITY)

Performance test by students:

1. Level and fine grade foundation sub-grade
2. Remove all debris, roots, vegetation from sub-grade
3. Hand test sub-grade for optimum moisture content
4. Add drying agents and work sub-grade as required
5. Determine necessary compactable backfill for foundation cushion
6. Distribute, level, and compact backfill within acceptable tolerances according to specifications
7. Dig all foundation beam trenches according to blueprint plans and details

V. SUMMARY (TELL THE STEPS ON PROCEDURE AS TO WHAT, HOW, AND WHY. REVIEW CHECKING STANDARDS. THIS SUMMARY MAY BE GIVEN AT ANY PLACE IN THE LESSON THE TEACHER FEELS WILL BE PROFITABLE TO THE STUDENTS.)

One of the most important factors in determining foundation requirements is the soil, or ground, on which the foundation rests. A soil analysis should be made immediately and load requirements ascertained of the site area before building foundations are erected. Any precautions and soil modifications should be adhered to during sub-grade preparation to insure a sound and lasting foundation.

Since the slab and beam foundation utilizes the beam trenches as concrete forms below grade, the soil modification or conditioning should take place before the trenches are dug. The sub-grade should be loosened, scraped, and leveled to specifications; cleared of all roots, vegetation, foreign matter and debris; required chemicals, minerals, and backfill added to stabilize the soil, improve the load bearing qualities, and obtain its optimum moisture content; then compacted to the sub-grade elevation to form a level cushion for the foundation slab. The use of grade stakes with string lines stretched between building lines aid greatly in the control and leveling of the sub-grade.

Once the sub-grade is prepared, building lines are quickly re-established and beam trenches located and laid out according to blueprint plans and details. (Underground plumbing may also be done at this time.) Dimensions should be double checked before any excavation begins. Excavation may be by trench machine or by hand, but either way, care should be exercised that outside trench walls be straight, vertical, and on the building foundation lines; inside walls be straight and parallel with correct angle of repose; and trenches correct width and depth. Earth removed during excavation should be placed outside the building lines to be distributed evenly over the building site or disposed of in some acceptable manner, and all trenches should be cleaned of debris and tamped firm and level.

SUGGESTED READING FOR THE STUDENT:

Modern Carpentry, pp. 89-110
Fundamentals of Carpentry, pp. 54-105

The Next Lesson Is: II-B-1(S), "Erect Forms For Slab And Beam Foundation"

JOB SHEET
IN
BUILDING SITE PREPARATION

II-A-6(J)

NAME OF JOB: Prepare Sub-base For Slab And Beam Foundation

MATERIAL: Soil stabilizing and/or drying agents as per specifications, foundation base (cushion) material as per specifications, nylon cord, surveyor's laths

TOOLS AND EQUIPMENT: Rakes, 3 lb. engineer's hammer, picks, tampers (hand and pneumatic), shovels, wheelbarrows

GENERAL INSTRUCTIONS: Some soils require modification to be suitable for a building sub-base. Soil modification is of two types: (1) soil stabilization and (2) moisture control. Soil stabilization involves the introduction, mixing, and compaction of other soils and minerals to improve the native soil's load bearing qualities. Study foundations plans, details and specifications to maintain appropriate levels when working sub-base.

PROCEDURE AND/OR TASK:

1. Check grade level of sub-base to be T. O. C. elevation minus slab thickness minus compactible fill thickness
2. Bring sub-base to proper level using hand and/or power tools. Remove all foreign matter and debris
3. Add stabilizing and drying agents as required — blend lightly with loosened sub-grade using rakes

CHECK POINTS: Stabilizing and drying agents may be caustic. Wear appropriate safety apparel as necessary.

4. Calculate and add compactible backfill as per plans and specification
5. Distribute evenly over entire foundation area and compact using pneumatic/hand tampers
6. Check level and elevation using string lines stretched over building string lines — cut, fill, tamp level as required

INSTRUCTOR'S PLAN
INFORMATIONAL LESSON

II-B-1(I)

SUBJECT: Concrete Forms

AIM: The students will be able to identify different types of concrete forms, name their component parts and explain the function of each. The students will further be able to explain proper construction-erection procedures for each type.

TEACHING AIDS: Chalkboard, O/H Transparencies
Information Sheets II-B-1(IS), II-B-1a(IS), Assignment Sheet II-B-1(A)

MATERIALS: Chalk

REFERENCES: *Modern Carpentry*, Unit 6
Fundamentals of Carpentry, Chapter 3

PREREQUISITE EXPERIENCE OF THE LEARNER: The student must have successfully passed all previous safety tests, exhibit proficiency in the use of carpenter's hand tools and display the ability to read and interpret blueprints.

I. PREPARATION (OF THE LEARNER - MOTIVATION)

Building contractors who build large numbers of residences plan and use repeatedly the same or similar foundation plan. With a little forethought, floor plans can be redesigned, rooms rearranged, and building styles changed to conceal the fact that several residences in the same neighborhood may share a common foundation plan.

This is done in the interest of economy--and as a time saver. Forms may be prefabricated and used repeatedly with considerable savings of time and material. This practice, along with other standardized practices in concrete technology, has given rise to numerous commercial form systems which can either be purchased or rented, and to an increasing specialization in the building trades; the Foundation Contractor.

The Foundation Contractor works with specialized crews who erect forms, set reinforcement steel, place and work plastic concrete, set anchoring devices, and finish concrete surfaces. In addition, they remove, clean, and maintain prefab forms for repeated use. Although this specialization is gaining in popularity, each Building Trades student should become familiar with concrete form construction for he/she may be called on at any time to construct and/or erect some type of concrete form, and who knows, maybe it will become your specialty.

II. PRESENTATION (OR THE INFORMATION)

	INSTRUCTIONAL TOPICS TEACHING POINTS	THINGS FOR STUDENTS TO DO THINGS FOR INSTRUCTOR TO DO OR SAY
A.	Action of Wet Concrete	1. Combination of aggregates, cement, water 2. Forms a semi-liquid paste 3. Acts like a liquid for short duration a. Flows like a thick milkshake b. Exerts lateral pressures equal its weight uniformly in all directions c. Must be contained 4. Referred to as "plastic" while in this state 5. Must be worked/molded while plastic 6. Sets, or hardens, due to internal chemical reactions
B.	Purpose of Forms	1. Acts as a mold 2. Contains plastic concrete until it hardens 3. Shapes concrete to design specifications 4. Forms desired surfaces 5. In building construction: a. Holds concrete to given lines b. Holds concrete to given grades
C.	Types of Forms	Note: Two Major Categories 1. Commercial forms 2. Fabricated forms
	1. Commercial Forms	1. Several commercial systems on market 2. Based on modular construction - unit panels of standard sizes 3. May be assembled to varying sizes; shapes 4. Assembled thru interlocking devices or means 5. Construction usually lightweight, strong a. Metal frame back b. Plastic or metal panels 6. Follow manufacturer's instructions for assembly
	2. Fabricated Forms	1. Are generally constructed for a particular job 2. Are generally constructed of wood 3. Are generally constructed on the job site

4. Are generally dismantled and the wood reused in the building construction

D. Form Parts

1. Sheathing - holds plastic concrete in place
    a. Shapes and forms the concrete surface
    b. Provides desired surface finish

Passout: II-B-1(IS)

2. Studs - supports sheathing
    a. Vertical supports
    b. Minimizes deflection (bowing)
    c. Used to nail panels together
3. Wales - supports studs against deflection
    a. Lateral supports
    b. Helps align form panels
    c. Used to secure ties
4. Braces - support against lateral movement
    a. Windloads
    b. Construction
5. Ties, spreaders, tie-spreader unit
    a. Holds form walls at correct distance apart
    b. Keeps form walls from spreading

E. Form Materials

Note: As on-site form construction is our major concern, this lesson deals exclusively with on-site construction and erection

1. Framing Lumber

1. Milled primarily from four varieties of native (coniferous) softwood
    a. Southern yellow pine
    b. Douglas fir
    c. Spruce
    d. Hemlock
2. Used for construction because it's relatively
    a. Strong
    b. Straight grained
    c. Lightweight
    d. Easy to work
    e. Abundant
3. Often called "dimension lumber" because it is milled in standard sizes
    a. Thickness - 2" to 4"
    b. Widths - 2" thru 12" in 2" intervals
    c. Lengths - 6' thru 20' in multiples of 2'

Note: Dimensions above refer to "nominal sizes" Actual sizes are scant as milled lumber loses ½" in thickness and width due to curing and surfacing. Lengths are unaffected

4. Graded primarily on basis of strength
    a. Uses number system 1 thru 3
    b. Number indicates relative amount of defects allowed
5. Grades
    a. No. 1 - allows small, tight knots, pitch pocket, other defects that do not impair strength
    b. No. 2 - slightly less strength than No. 1 used in "standard" construction framing
    c. No. 3 - allows large knots, knot holes decay, and checks. Referred to as "utility" lumber

Note: Only No. 1 or select No. 2 dimension lumber should be used in concrete form construction

2. Plywood

1. Manufactured wood product
    a. Wood rotary turned(peeled) from logs into thin layers
    b. Layers called plies
    c. Plies stacked cross-grain for strength; different thicknesses
    d. Plies laminated under head and pressure into large sheets
2. Standard sizes
    a. 4' x 8' sheet size
    b. 1/4" - 1 1/8" sheet thickness in 1/8" increments
3. Types - (2) major types
    a. Interior
    b. Exterior
4. Grades A thru D: indicate quality of veneers
    a. Grade "A" best - smooth, paintable; neatly made repairs permissible
5. b. Grade "D" worst - called utility; allows knots, knot holes, splits
    c. Grade "N" - special order

3. Plyform

1. Proprietary name

2. Made especially for concrete forms
3. Manufactured by member mills of the American Plywood Association
4. Specifications
   a. Two classes; Class 1 - greater strength
   b. Exterior type
   c. B-grade faces
   d. Standard size 4' x 8'; thickness ½"-1 1/8"
   e. Edges sealed; faces treated

F. Form Design

1. Depends on whether the pour is horizontal or vertical
2. Is important when pour is vertical

1. Considerations

1. Weight of concrete
   a. Per cubic foot
   b. Rate of placement (height x time)
   c. Temperature of concrete in forms
   d. Uniform lateral loads - lbs./ft.
2. Type and size of material
3. Spacing of support (framing) members
   a. Studs and joists
   b. Wales
4. Economics
   a. Availability and cost of material
   b. Potential reuse of material in building

2. Requirements

1. Strong enough to support any/all loads imposed by placement of concrete
2. Tight enough to prevent leakage of plastic concrete during placement and consolidation
3. Hold proper alignment and true to grade
4. Braces against movement
5. Easy removal upon completion

3. Calculations

1. Formulas
   a. Areas
   b. Volumes
   c. Board feet
2. Applications
   a. Excavations (cut and fill)
   b. Cubic yards of concrete required

Passout: I-B-1a(IS)

3. Discuss information sheet with class
   a. Place examples on chalkboard
   b. Work examples with class

G.	Construct/Erect Outside Wall Form	1. Study foundation plans; details a. To become familiar with job requirements b. To calculate form requirements 2. Design forms as necessary (see step "F", this lesson) 3. Construct form panels as per design factors Note: Panels may be constructed in the shop and moved to the site
1.	Establish Building Corners, Building Lines	1. On foundation footing 2. With plumb-bob a. Suspend at intersection of stringlines b. Stringlines taut on batterboards 3. With chalk, chalkline a. Mark exact points (corners) b. Snap chalkline between points
2.	Position Outside Form Panels	1. One-at-a-time 2. Start at one corner a. With panel face in 3. Position panel base to chalkline 4. Position panel top to stringline (on batterboard) 5. Position panel sides butted and aligned flush Note: On outside form corners one panel may overlap. On inside form corners, filler panels should be constructed after all other panels are in place
3.	Nail Panels Together	1. With 16d duplex-head nails 2. Spaced 10-12" apart 3. Thru vertical supports a. On back side of panel b. At each end of panel c. While positioned and aligned
4.	Brace Outside	1. One wall-at-a-time 2. While holding in place a. Base to chalkline on footing b. Top to stringline on batterboards 3. On 8'-0 intervals, or as required and uniformly spaced 4. Positioned horizontal brace members

  - a. On edge on top of panel sole
  - b. Against vertical support and back of panel
  - c. Extending out 90° from back of panel

5. Set stakes
   - a. Use horizontal braces and one diagonal brace as a guide to locate
   - b. Side flush to sides of brace members
   - c. Drive stakes vertically into ground-firm!
   - d. Allow ample projection to nail both braces

6. Position inclined brace members
   - a. Similar as horizontal braces
   - b. At appropriate angle
   - c. One-at-a-time

7. Secure braces
   - a. To panel vertical supports
   - b. To brace stakes
   - c. With 16d duplex-head nails
   - d. One-at-a-time
   - e. While holding form in position

5. Install Wales

1. Number, spacing, material, according to design calculations
2. Position horizontally
   - a. Outside of vertical supports
   - b. At correct height
   - c. Edge of whaler to back of supports

Note: 2" x 4" shorts cut to proper length may be used as vertical spacers

3. Toe-nail whalers to supports with 12d duplex-head nails

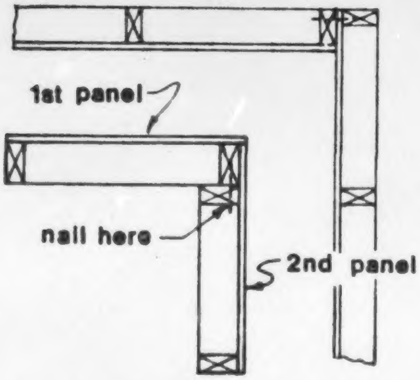
H. Drill Tie Holes

1. In form panels
2. At proper spacing
3. Using long shank drill
4. Size as per manufacturer's instructions

1. Position Inside Panels

1. Inside, against outside panels
   - a. In upright position
   - b. With faces butted together
2. In correct lineal position
   - a. Butted together end-to-end

		b. With equal space at each end between outside forms
	2. Lay Out Holes	1. As per design calculations (spacing) 2. On outside wall form a. Measure linear spacing along top wale b. Use wale spacing for vertical spacing Note: In most forms, ties are placed at the same spacing as wales and the wales are used to help secure the ties 3. Follow tie manufacturer's instructions
	3. Drill Holes	1. Thru both form panels at one time 2. Size as per tie manufacturer's instructions 3. Follow safe operating procedures if using power (electric) drill
I.	Construct/Erect Inside Wall Form	1. Lay inside panels back 2. Sweep footing clean 3. Mark location of inside wall a. With chalk and chalkline b. Measure wall thickness c. Near each end inside of form d. Snap chalkline on foundation footing e. Thru points marked 4. Position inside form panels to chalkline similar as per step "H-1" above Note: Install wall ties as each panel is installed 5. Nail panels together similar as step "G-3" this lesson
J.	Construct Filler Panels	1. For inside corners one corner at-a-time 2. After all other wall forms are in place 3. Measure panels accurately a. From bottom end of inside wall form b. To inside corner of foundation wall marked on foundation footing c. Each wall forming inside corner 4. Cut panels a. One to size (length measured) b. One to size less panel wall thickness c. Cut square, straight, clean
	1. Construct 1st Panel	1. Cut sole and top plate from 2" x 4" stock a. Accurately; square



Inside Corner Construction
WALL FORMS

  - b. Length equal panel width minus panel thickness
- 2. Cut vertical supports - (2) each panel
  - a. Accurately; square
  - b. Length equal panel height minus 3"
- 3. Nail plates, vertical supports into a box frame
  - a. Position members on edge in a box frame
  - b. Supports butted into plates
  - c. Spike thru plates into supports while holding frame square
  - d. With 16d common nails set flush
- 4. Nail frame to panel
  - a. Flush at top, bottom, side away from corner
  - b. With 6d common nails set flush
  - c. Spike thru panel face into frame

2. Construct 2nd Panel

- 1. Cut sole and top plate
  - a. Accurately; square
  - b. Length equal panel width minus $3\frac{1}{2}$"
- 2. Nail plates, vertical supports into a box frame similar as 1st panel
- 3. Nail box frame to form panel similar as previous panel

NOTE: Flush at top, bottom, side away from corner

3. Assemble Panels

- 1. To form inside corner
- 2. Position panels in a vertical position
- 3. Fit panels together squarely so that panels form edge butt joint
- 4. Nail panels together with 16d duplex-head nails
  - a. Thru vertical support - panel # 2
  - b. Into vertical support - panel # 1

K. Install Corner Panels

NOTE: Sweep top of foundation footing clean between wall forms before closing in corners. Make exerted effort to keep footing clean inside forms from this point on

- 1. Position assembled corner panel
- 2. To inside corners one-at-a-time

- a. Panel faces to chalk lines on foundation footings
- b. Panels butted flush to existing panels

3. Nail to existing panels
    - a. With 16d duplex-head nails
    - b. Spike thru vertical supports
    - c. While holding in place

L. Complete Wall Forms

1. Set inside wales as required
    - a. Similar as outside form wales
    - b. Opposite outside form wales
2. Check position, and affix all form ties

NOTE: Follow manufacturer's specifications and directions on all installation of all form ties

3. Complete all braces similar as per previous braces

M. Check Form Construction

1. To be dimensionally correct
    - a. Overall dimensions: out-to-out
    - b. Wall thicknesses
    - c. Wall heights level
2. For proper alignment
    - a. Forms straight
    - b. Forms plumb
    - c. Corners square
    - d. Joints butted flush
3. For strength
    - a. Ties positioned properly
    - b. Braces rigid
    - c. Construction firm; sound
    - d. Joints solid

III. APPLICATION (DRILL, ILLUSTRATIONS, ANALOGIES, ORAL QUESTIONS OR ASSIGNMENTS, MAKING ILLUSTRATIONS OR EXPERIMENTS, NOTE TAKING, MAKING SKETCHES, PARTICIPATING IN DISCUSSION.)

Passout: Assignment sheet II-B-1(A)
Students complete assignment as per instructions
Class discussion over questions and answers

IV. VERIFICATION AND/OR EVALUATION (FINAL CHECK ON STUDENT'S COMPREHENSION OF MATERIALS PRESENTED.)

Simple Recall:

1.	The correct combination of aggregates, cement, and water produces _____.	concrete
2.	Freshly mixed concrete (in semi-liquid form) is referred to as _____ concrete.	plastic
3.	The primary purpose of concrete forms is to _____ plastic concrete until it cures.	contain
4.	That part of the concrete form which supports studs against deflection is called _____.	wales
5.	That part of the forms which is responsible for wall surface texture is the _____.	sheathing
6.	Another name for framing lumber is _____ lumber.	dimension
7.	Actual dimensions of a nominal 2" x 4" are _____.	1 ½" x 3 ½"
8.	The preferred grade of framing lumber for concrete form construction is _____.	No. 1
9.	Framing lumber may be purchased in standard lengths from 6' to _____ feet in 2' intervals.	20
10.	No. 3 grade framing lumber is often referred to as _____ grade.	utility
11.	The standard size sheet of plywood measure _____ feet.	4 x 8
12.	There are basically 2 types and _____ grades of plywood.	4
13.	Made especially for concrete forms by member mills of the American Plywood Association is _____.	Plyform
14.	Concrete used in most residential foundations weighs approximately _____ pounds per cubic foot.	150
15.	The formula for figuring the area of a rectangle is _____.	L x W
16.	A 4" concrete slab measuring 15' x 27' would contain _____ cubic yards of concrete.	5
17.	The volume of concrete required for a 9" thick foundation wall 8' high and 45' long is _____ cubic yards.	10

IV. VERIFICATION (CON'T.)

18. For ease of removal, concrete forms should be assembled with _____ nails. duplex-head

19. In building construction foundation forms must be erected to "lines" and to _____. grade(s)

20. The last form panels to be set in place in wall form construction are _____. inside corners

---

V. SUMMARY (GIVE A BRIEF ACCOUNT OF EACH TOPIC REEMPHASIZING THE IMPORTANT POINTS. THIS SUMMARY MAY BE GIVEN AT ANY PLACE IN THE LESSON THE TEACHER FEELS WILL BE PROFITABLE TO THE STUDENT.)

Wet concrete - combination of aggregates, cement, water; forms a semi-liquid paste, acts like a liquid, that is, exerts lateral pressures equal its weight uniformly in all directions - referred to as plastic while in this state - must be worked while plastic - must be contained - hardens due to internal chemical reactions.

Purpose of forms - acts as a mold - contains plastic concrete until it hardens - shapes concrete to design specification - forms desired surfaces - holds concrete to line; to grade.

Form requirements - must be strong enough to resist loads (lateral pressures) imposed by placement of plastic concrete - must resist all movement; hold true to line and grade - must be tight construction; prevent leakage of plastic concrete - must be constructed for easy removal upon completion.

Form design - must meet requirements yet conform to economics - selection of sheathing, studs, wales, braces, and their spacing which involves calculations of areas, volumes, weights, pressures, and uniform loads.

Form construction (wood fabrication) utilizes primarily plywood and framing lumber. Framing lumber, often called dimension lumber because it is milled in standard sizes, 2" - 4" thick, 2"-12" widths, and 6'-20' lengths, comes in three grades, 1, 2, 3. No. 1, being the top or best grade, is preferred for form construction. Framing lumber is milled primarily from Southern yellow pine, Douglas fir, spruce, and hemlock because it is relatively strong, straight grained, lightweight, and abundant. Plywood is a manufactured wood product rotary peeled from logs, wood layers/plies are stacked cross-grain and laminated under heat and pressure into sheets ranging from $\frac{1}{4}$" to 1 1/8" thickness and 4' x 8' standard sizes - comes in four grades, A, B, C, D, -

A being the top/best grade - "Plyform" manufactured by member mills of APA is made especially for form construction - has B faces with edges sealed and surfaces treated for repeated use.

Construction procedures - low horizontal forms such as concrete slabs present no special problems - generally 2" framing lumber the proper width, set to line and grade and properly staked is sufficient - walls forms require more planning - study architectural plans and details - design and construct required form panels - erect outside wall forms first; to line, to grade - assemble panels and braces with 16d duplex-head nails for easy removal and disassembly - set wales as per design requirements - position inside panels against outside panels allowing equal distance at each end for inside corners-drill tie holes as per design - position any reinforcement steel at this time-erect inside wall forms to line; to grade similar as outside forms installing necessary tie/spreaders as each panel is positioned - nail and brace similar as outside forms. Construct and install each inside corner filler panel - check construct for strength, alignment, tight, dimensionally correct.

SUGGESTED READING FOR STUDENTS:

The World of Construction, pp. 220-225
Methods and Materials of Commercial Construction, pp. 85-87

THE NEXT LESSON IS: II-E-1(I), "Concrete Reinforcement"

INFORMATION SHEET

ON

CONCRETE FORMS

SUBJECT: Concrete Form Construction

INTRODUCTORY INFORMATION:

Freshly mixed concrete is a combination of aggregates and a cement/water paste forming a semifluid substance. This substance acts as a liquid for a short period of time, and during this period it is referred to as "plastic" concrete. It is also during this period while concrete is plastic that it must be cast and worked into a desired shape. Since it acts like a liquid, it must be contained in a type of mold until chemical reactions within allow it to take initial set -- harden to a point it will maintain its shape and support its own weight.

GENERAL INFORMATION:

In building construction, these molds are called "concrete forms". There are many types and sizes of concrete forms, all of which perform the same basic function: to hold the semiliquid, or plastic concrete, in a desired size and shape until it takes initial set. In addition, on-site foundation forms must hold the plastic concrete in a given location; to given building lines; to given building grades. To do so, these forms must be strong and well braced; they must be tight, smooth, and properly aligned. Remember, concrete, at the time it is poured (placed), is plastic; a semiliquid which acts like a liquid. That is, it exerts pressures (lateral forces equal to its weight) uniformly in all directions. Concrete forms must be designed and constructed with above considerations in mind otherwise bulging, distortion and/or leakage will occur. The most frequent used materials for foundation form construction, not commercially bought forms, is plywood sheathing (soft plywood) and framing lumber.

Plywood is a manufactured wood product composed of thin layers of wood peeled (rotary turned) from logs, stacked cross-grain with each other and glued under pressure into large sheets; the most common size being 4' x 8'. Common thicknesses range from 1/4" to 1-1/8".

Plywood, because of its stability -- cross-ply construction makes strong stable panels both directions; its versatility -- ability to be worked with conventional carpenters' tools and skills; and its availability -- easily purchased in a variety of grades and thicknesses -- is ideal for form panels. Most DFPA grade-trademarked exterior plywood is acceptable for concrete form construction. However, "Plyform" (proprietary name), a plywood panel manufactured by member mills of the American Plywood Association is made specifically for concrete forms. It comes in two classes, class I having greater strength and stiffness. Plyform is of exterior type with grade-B surfaces, and is edge sealed and surface treated to withstand many reuses. Plyform should be considered if forms are to be used more than a few times.

Framing lumber is made primarily from four varieties of native coniferous wood: Southern yellow pine, Douglas Fir, spruce, and hemlock. These woods are used for framing and construction because they are relatively strong, straight grained, lightweight, easily worked, and abundant. Southern yellow pine is found from Virginia to Texas. Framing lumber, often called dimension lumber because it is milled in standard thicknesses (2" to 4"), widths (2" thru 12" in 2" intervals), and lengths (6' thru 20' in multiples of 2') is used for form supports and form braces. The dimensions above refer to nominal sizes. Actual sizes of milled lumber are scant since the wood must be seasoned and smoothed (surfaced) after it is cut. Framing lumber loses $\frac{1}{2}$" in thickness and width due to curing and milling; lengths are unaffected. Dimension lumber is graded primarily on the basis of strength using a numbering system of 1 thru 3; the number indicating the relative amount of defects allowed:

No. 1 dimension lumber allows small tight knots, pitch pockets, and other defects that do not impair strength.
No. 2 dimension lumber slightly less strength than No. 1 and is used in "standard" construction framing.
No. 3 dimension lumber allows large knots, knot holes, decay, and checks, and is referred to as "utility" lumber.

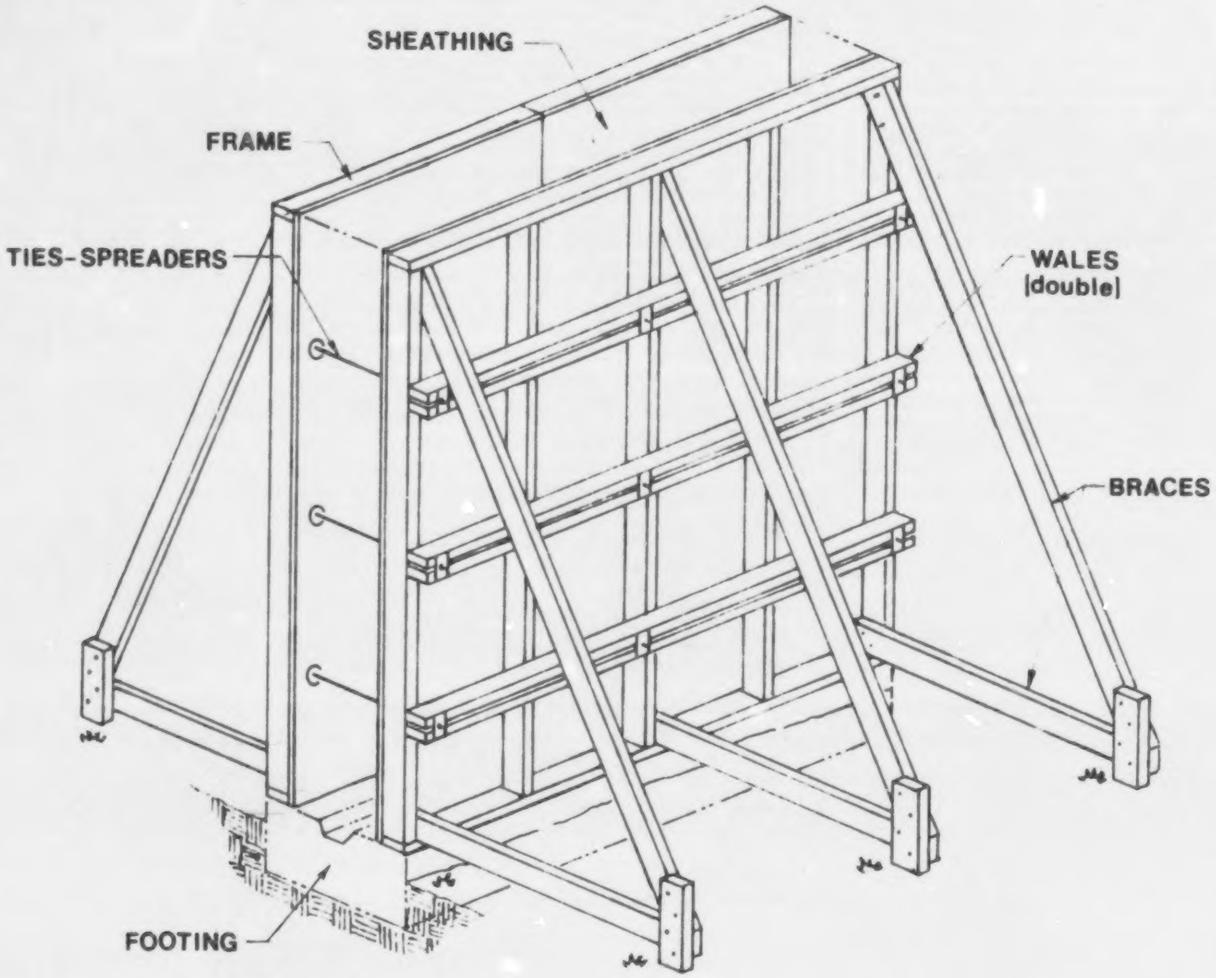
Only No. 1 dimension or select No. 2 dimension lumber should be used in concrete form construction.

Low walls forms up to about 3 ft. in height can be assembled from 3/4" plywood sheathing supported by 2" x 4" frame with studs spaced 2 ft. apart. The height can be increased somewhat if the studs are spaced closer together. Wall forms over 4 ft. in height should be backed by wales for greater strength.

Wood forms should be assembled with duplex-head nails where possible (panel joints, brace connections) for ease in disassembly and removal of forms.

On extensive wall forms, refer to the booklet Plywood For Concrete Forming published by the American Plywood Association to determine form design factors such as sheathing thickness, stud size, spacing, and wales size and spacing.

TYPICAL WALL FORM

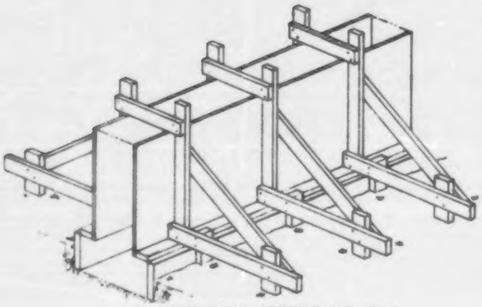


All wood wall forms are made of five basic elements:

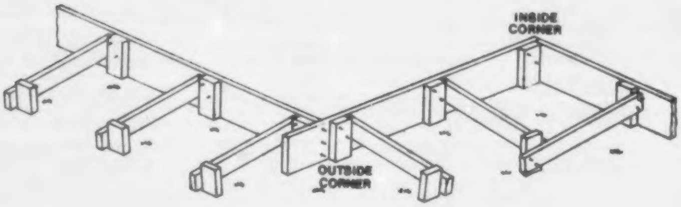
1. Sheathing or panels - shapes and forms the surface of the concrete; provides desired surface finish; keeps concrete in place until it hardens.
2. Frame - composed of studs and plates; supports sheathing and minimizes deflection (bowing).
3. Wales - align the forms; secure the ties; support the studs against deflection.
4. Shoring/braces - provide lateral support against construction; wind loads, movement.
5. Ties, spreaders, tie-spreader units - keep the sides of the forms from spreading as a result of lateral pressure of freshly poured concrete.

TYPICAL CONCRETE FORMS USED IN HOME AND BUILDING CONSTRUCTION

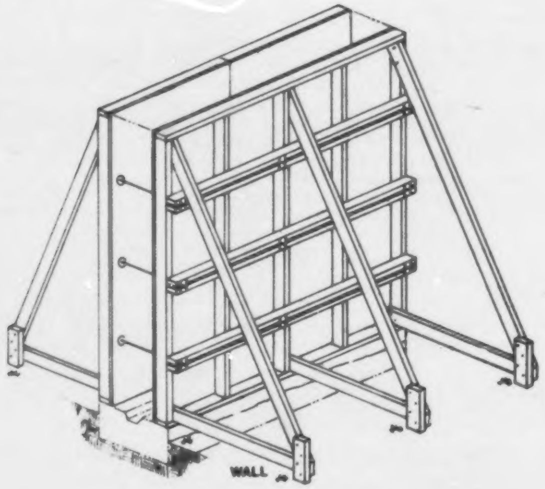
II-B-1(IS)



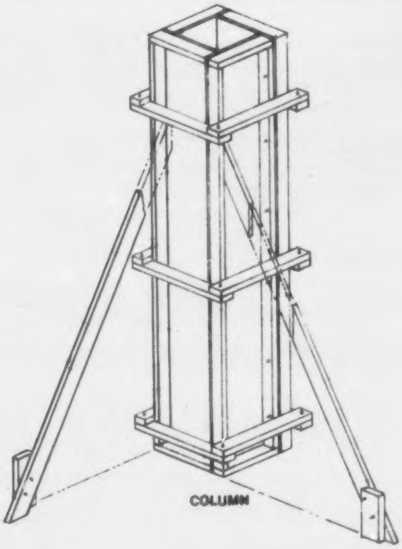
MONOLITHIC FOOTING AND WALL


INSIDE CORNER
OUTSIDE CORNER

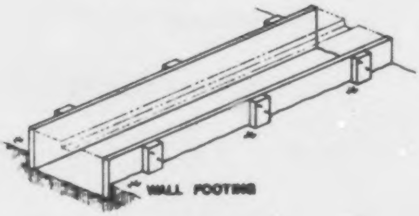
SLAB



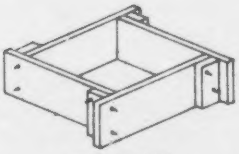
WALL



COLUMN



WALL FOOTING



PIER FOOTING

II-B-1a(IS)

INFORMATION SHEET
ON
CONCRETE FORMS

SUBJECT: Wall Form Design

INTRODUCTORY INFORMATION:

Freshly mixed concrete must be placed in forms to cure (harden) into a desired shape. As stated previously, freshly mixed concrete, plastic concrete, is a combination of aggregates and a cement/water paste forming a semiliquid that acts like a liquid; that is, it exerts pressures/lateral forces equal to its weight uniformly in all directions.

Concrete forms must be strong enough to support any/all loads imposed upon them during placement of the concrete; hold the concrete to "line and grade" until it has gained sufficient strength (cured to initial set); and be designed and built for easy removal and possible reuse.

GENERAL INFORMATION:

The design of concrete forms depends to a great extent on whether the pour is horizontal or vertical. Low, horizontal forms such as for thin concrete slabs and footings present no special design problems. Generally, framing lumber (2" stock) the proper width, well staked/braced is sufficient. However, vertical forms such as for walls and columns, must be given special design consideration as the amount of lateral pressures involved is compounded by the vertical height of the pour.

The amount of lateral pressures involved is dependent on the following factors:

1. The weight of the concrete per cubic foot. Most concrete used in residential construction (concrete made with natural aggregates) weighs between 140 and 150 pounds per cubic foot.
2. The vertical height to be poured per hour, called the rate of placement. (The amount of fresh/plastic concrete in the forms.)
3. The temperature of the concrete mix (generally the same as ambient temperature) plus other variables which have minimal effect.

Pressures must be calculated and material types, sizes, and spacings carefully selected and employed to safely and economically design and construct forms made of plywood sheathing, wood studs, joists, and wales.

The following procedures, formulas, and tables (partial) were developed by the American Concrete Institute (ACI) to aid in the design of wooden concrete forms.

Follow them closely!

1. Calculate the maximum pressure (psf) that will be exerted on the wall forms (Refer to Table I).
    - a. Select appropriate value from table and/or work appropriate formula.
    - b. Multiply 150 x height (rate of placement) feet per hour.
    - c. Use 2000 pounds per square foot (psf) maximum design pressure.
    - d. Select lowest value for design purposes (see example - Table I),
2. Determine maximum span (spacing) for studs.
    - a. Identify type, grade of framing lumber to be used.
    - b. Determine if sheathing will be continuous over three or more supports or a simple span between two points.
    - c. Select maximum spacing according to material size and equivalent uniform load (lb/ft) (See Table II).

Example: Assume form panels will be continuous over 1 or 2 spans.
Stud material and size is No. 1 Southern Pine 2" x 4"s.
Use 750 lbs. (from 1st example) as equivalent uniform load.
Read Table II "Maximum Span For Studs" -- 24" on center.

3. Select plywood sheathing and final stud spacing based on allowable pressure (psf) and maximum stud spacing established in steps 1 and 2.
    - a. Study tables, "Allowable Pressures - Plywood Wall Forms", Table III. There are several possibilities!
      With "Face Grain Across Supports" we have:
        1/2" - class II, maximum spacing: 8" on center
        3/4" - class I, maximum spacing: 12" on center
      With "Face Grain Parallel Supports" we have:
        5/8" - class I, maximum spacing: 8" on center
        3/4" - class II, maximum spacing: 10" on center (avg.)
        1" - class I, maximum spacing: 16" on center
    - b. Make selection based on economics, availability of material, ease of panel layout and construction, and possible reuse of material in the building construction.
      Answer: 3/4" class I plyform, face-grain across studs on 12" centers
4. Select wales size and spacing based on equivalent uniform load, wale size and type material, and whether a simple span or continuous over several supports.
    - a. Assume wales are on a given spacing - example: 4'-0" on center; other data as per previous examples.

b. Compute equivalent uniform load - 4' x 750 psf = 3000 lb./ft.

c. Make selections from Table IV, "Maximum Span of Double Wales". There are several possibilities!

   1) double 2 x 4; 16" on center
   2) double 2 x 6; 26" on center
   3) double 2 x 8; 34" on center

d. Revise assumed spacing - example: 2'-0" on center and recompute equivalent uniform load - 2' x 750 psf = 1500 lb./ft.

e. Reselect! There are several possibilities!

   1) double 2 x 4; 24" on center
   2) double 2 x 6; 38" on center
   3) double 2 x 8; 50" on center

f. Make final selection based on material availability and economics (cost and possible reuse of material in building frame).
   Final selection: double 2 x 4 wales spaced 2'-0" on center

Note: For a complete set of tables covering other types and grades of framing lumber refer to formulas and charts as listed in ACI 347-68, "Recommended Practice For Concrete Form Work".

TABLE I

MAXIMUM LATERAL PRESSURES

VERTICAL WALL FORMS

Based on ACI Committee 347 pressure formulas with normal internal vibration where:

p = Lateral Pressure, PSF
R = Rate of Placement, ft. per hr.
T = Temperature of concrete in forms, deg. F.
h = Height of Fresh Concrete above point considered, ft.

When R does not exceed 7 ft. per hr., use

$$p = 150 + \frac{9000\,R}{T}$$

When R is greater than 7 ft. per hr., use

$$p = 150 + \frac{43400}{T} + \frac{2800\,R}{T}$$

RATE OF PLACEMENT FT. PER HR.	MAXIMUM LATERAL PRESSURE P.S.F. for temperature indicated 90° F	80° F	70° F	60° F	50° F	40° F
1	250	262	278	300	330	375
2	350	375	407	450	510	600
3	450	488	536	600	690	825
4	550	600	664	750	870	1050
5	650	712	793	900	1050	1275
6	750	825	921	1050	1230	1500
7	850	938	1050	1200	1410	1725
8	881	973	1090	1246	1466	1795
9	912	1008	1130	1293	1522	1865
10	943	1043	1170	1340	1578	1935

Note: Do not use design pressures above 2000 psf or 150 h, whichever is less.

Example: Placement rate 5 ft/hr; Concrete temp. 70° F

from formula/chart: $150 + \frac{9000 \times 5}{70} = 793$ psf or..

$150 \times 5 = 750$ psf or..

2000 psf max. whichever is less

Answer: 750 psf

TABLE II

Maximum Spans For Studs And Joists, Inches
No. 1 Southern Pine, or Douglas Fir

Equivalent uniform load lb/ft	Continuous over 2 or 3 supports (1 or 2 spans)								Continuous over 4 or more supports (3 or more spans)							
	Nominal size								Nominal size							
	2×4	2×6	2×8	2×10	2×12	4×4	4×6	4×8	2×4	2×6	2×8	2×10	2×12	4×4	4×6	4×8
400	40	58	77	98	117	52	82	104	43	65	86	110	133	65	99	122
600	30	47	62	80	97	46	72	94	31	49	64	82	100	56	81	107
800	24	38	50	64	78	42	63	83	25	39	52	66	81	48	70	93
1000	21	33	43	55	67	39	56	74	21	34	44	57	69	41	63	83
1200	19	29	88	49	60	34	51	68	19	30	39	50	61	35	55	73
1400	17	27	35	45	54	30	47	62	17	27	36	46	56	31	49	64
1600	16	25	32	41	50	27	43	56	16	25	33	42	52	28	44	58
1800	15	23	30	39	47	25	39	52	15	24	31	40	48	26	40	53
2000	14	22	29	37	45	23	36	48	14	22	29	38	46	24	37	49
2200	13	21	28	35	43	22	34	45	14	21	28	36	44	22	35	46
2400	13	20	26	34	41	20	32	42	13	20	27	34	42	21	33	44
2600	12	19	26	33	40	19	31	40	13	20	26	33	40	20	31	41
2800	12	19	25	32	38	19	29	38	12	19	25	32	39	19	30	39
3000	12	18	24	31	37	18	28	37	12	19	24	31	38	18	29	38
3200	11	18	23	30	36	17	27	35	12	18	24	30	37	18	28	36
3400	11	17	23	29	36	17	26	34	11	18	23	30	36	17	27	35
3600	11	17	22	29	35	16	25	33	11	17	23	29	35	16	26	34
3800	11	17	22	28	34	16	24	32	11	17	22	29	35	16	25	33
4000	10	16	22	28	34	15	24	31	11	17	22	28	34	15	24	32
4500	10	16	21	27	32	14	22	29	10	16	21	27	33	14	23	30
5000	10	15	20	26	31	13	21	28	10	16	20	26	32	14	22	28

NOTE: SPANS ARE BASED ON PS-20 LUMBER SIZES.
SPANS ARE CENTER TO CENTER OF THE SUPPORTS.

TABLE III

ALLOWABLE PRESSURES (psf) – PLYWOOD WALL FORMS

(WITH FACE GRAIN ACROSS THE SUPPORTS)

PLYFORM CLASS I

Support spacing	Thickness					
	1/2	5/8	3/4	7/8	1"	1-1/8
4	3190	4070	5010	5150	5590	6220
8	1030	1370	1740	1980	2150	2390
12	450	610	770	990	1240	1450
16	190	290	400	540	700	800
20	100	150	220	300	400	480
24			130	180	250	310
32					110	140
36						100

PLYFORM CLASS II

Support spacing	Thickness					
	1/2	5/8	3/4	7/8	1"	1-1/8
4	2990	3870	4780	4780	5140	5720
8	750	990	1260	1630	1980	2200
12	330	440	560	730	920	1080
16	160	240	310	410	520	610
20		130	180	250	330	390
24			110	150	210	260
32					100	120
36						

(WITH FACE GRAIN PARALLEL THE SUPPORTS)

PLYFORM CLASS I

Support spacing	Thickness					
	1/2	5/8	3/4	7/8	1"	1-1/8
4	1550	2250	2780	3740	4460	5280
8	550	870	1070	1440	1710	2030
12	160	380	660	890	1060	1260
16		160	330	520	770	910
20			170	270	420	570
24			120	200	300	390

PLYFORM CLASS II

Support spacing	Thickness					
	1/2	5/8	3/4	7/8	1"	1-1/8
4	1540	2240	2780	3740	4450	5270
8	350	750	1070	1440	1710	2030
12	100	230	470	700	1020	1250
16		100	200	320	480	630
20			100	170	260	350
24				120	190	250

NOTE: ALL PLYWOOD COTINUOUS ACROSS TWO OR MORE SPANS

TABLE IV

Maximum Span For Double Wales, Inches
No. 1 Southern Pine or Douglas Fir

Equivalent uniform load lb./ft.	Continuous over 2 or 3 supports (1 or 2 spans)									Continuous over 4 or more supports (1 or 2 spans)								
	Nominal size									Nominal size								
	2x4	2x6	2x8	3x4	3x6	3x8	4x4	4x6	4x8	2x4	2x6	2x8	3x4	3x6	3x8	4x4	4x6	4x8
1000	35	52	69	44	67	89	49	76	98	36	56	74	52	75	99	60	89	115
1200	30	47	62	41	61	81	46	72	94	31	49	64	47	69	91	56	81	107
1400	27	42	56	39	57	75	44	67	89	28	43	57	41	64	84	52	75	99
1600	24	38	50	36	53	70	42	63	83	25	39	52	37	58	77	48	70	93
1800	22	35	46	33	50	66	40	59	78	23	36	48	34	53	70	44	66	88
2000	21	33	43	30	47	62	39	56	74	21	34	44	31	49	64	41	63	83
2200	20	31	41	28	44	58	36	54	71	20	32	42	29	45	60	38	59	78
2400	19	29	38	26	41	54	34	51	68	19	30	39	27	43	56	35	55	73
2600	18	28	37	25	39	51	32	49	65	18	28	38	26	40	53	33	52	68
2800	17	27	35	23	37	49	30	47	62	17	27	36	24	38	50	31	49	64
3000	16	26	34	22	35	46	29	45	59	17	26	34	23	36	48	29	46	61
3200	16	25	32	21	34	44	27	43	56	16	25	33	22	35	46	28	44	58
3400	15	24	31	21	32	43	26	41	54	15	24	32	21	33	44	27	42	56
3600	15	23	30	20	31	41	25	39	52	15	24	31	20	32	42	26	40	53
3800	14	22	30	19	30	40	24	38	50	15	23	30	20	31	41	25	39	51
4000	14	22	29	19	29	38	23	36	48	14	22	29	19	30	39	24	37	49
4200	14	21	28	18	28	37	22	35	46	14	22	29	18	29	38	23	36	48
4400	13	21	28	17	27	36	22	34	45	14	21	28	18	28	37	22	35	46
4600	13	20	27	17	27	35	21	33	44	13	21	28	17	27	36	22	34	45
4800	13	20	26	17	26	34	20	32	42	13	20	27	17	27	35	21	33	44
5000	13	20	26	16	26	34	20	31	41	13	20	26	17	26	34	20	32	42

NOTE: SPANS ARE BASED ON PS-20 LUMBER SIZES.
SPANS ARE CENTER TO CENTER OF SUPPORTS.

II-B-1(AS)
(p. 1 of 2)
Key

ASSIGNMENT SHEET

IN

BUILDING TRADES

SUBJECT: Concrete Forms

AIM: The students will display the knowledge and skill necessary to design and construct conventional foundation forms for residential construction.

INTRODUCTORY INFORMATION: Foundation forms fall within the realm of the carpenter's responsibility. The carpenter must be fully capable of planning and constructing foundation forms from a given set of foundation plans and details which will be structurally sound and economically appropriate for the job. In order to do this, the carpenter must read and interpret blueprints, calculate concrete volumes and weights, translate the results into total lateral forces exerted, select appropriate material - size, type, arrangement, and spacing, compose a Bill of Material, and construct forms that will hold plastic concrete to "line" and "grade" within acceptable tolerances.

REFERENCES: Information Sheet II-B-1(IS) "Wall Form Design"

QUESTIONS OR PROBLEMS: Given a 20' x 40' building in which the foundation is a combination footing and wall within a 6" slab (see drawing). Using all available information from lesson II-B-1(IS) answer the following questions.

1. The size framing lumber most appropriate for the footing form boards is _____. 2" x 12"

2. The outside dimensions of the foundation footings are _____. 21' x 41'

3. Using the outside dimensions from question #2 as actual length and the size framing lumber (answer to question #1) for size compute actual board feet required for outside footing forms. (Ignore overlap) 248

4. The cross-sectional area of the foundation footing is _____ sq. ft. 2

	Key
5. The cross-section area of the footing and wall combined is _____ sq. ft.	6
6. The cubic yards of concrete required for the foundation footing is _____. (Figure to nearest 10th)	8.6
7. The cubic yards of concrete required for the foundation wall is _____.	17.2
8. The cubic yards of concrete required for the foundation slab is _____.	14.8
9. The total concrete required for the job is _____ cu. yds.	41
10. If the rate of placement (concrete) is 4' per hour at a temperature of 90°F the maximum lateral pressure for design purpose of wall forms is _____. Note: Use Table I from I-B-1a(IS) for calculations.	540
11. If the rate of placement were 2' per hour at a temperature of 60°F the psf would be _____.	450
12. Using 600 psf as the maximum lateral pressure and 2 x 4 No. 1 southern pine studs for vertical supports the maximum span would be _____ inches center to center.	30
13. The logical arrangement of plywood panels for the wall form would be with the face-grain _____ the supports. Using data from question #10, and Table III of II-B-1(IS).	across
14. The most appropriate sheathing material for the wall forms would be _____.	3/4" Class II Plyform
15. The appropriate stud spacing for the above sheathing, (question 14) would be _____ inches center to center.	12

INSTRUCTOR'S PLAN
MANIPULATIVE LESSON

II-B-1(S)

TASK:	Erect Forms For Slab And Beam Foundation
AIM:	The students will be able to erect functional foundation forms to a specified elevation; cut and prepare beam trenches for a monolithic slab and beam foundation according to blueprints and specifications.
TOOLS AND EQUIPMENT:	Tripod, plumb-bob, carpenter's level, hammers (sledge and claw), measuring tapes, hand saw, framing square, picks, shovels, rakes, tampers (hand and pneumatic), wheelbarrows
MATERIALS:	Form materials 2" x 6" or 2" x 8" lumber, 2" x 4" braces, 2" x 4" stakes, 2" x 2" hubs, string lines (nylon), 8d finish nails, 16d duplex-head nails
TEACHING AIDS:	Project foundation plans, sections, details; pencil, note pad
REFERENCES:	Modern Carpentry, Unit 6, pp. 87-110 Fundamentals of Carpentry, Chapter 3, pp. 65-79, 100-104
PREREQUISITE EXPERIENCE OF THE LEARNER:	The student must have successfully completed lessons I-B-2(I) Shop Rules and Regulations, I-D-1(I) "Personal and General Shop Safety," II-A-5(S) "Layout Building Lines and Erect Batterboards," II-A-6(S) "Prepare Sub-base For Slab and Beam Foundation"
CHECKING STANDARDS:	1. Follows proper building procedures 2. Proficient in use of tools, equipment 3. Efficient use of time, materials 4. Ability to perform tasks with successful degree of accuracy a. Selection of form material b. Positioning of form material (1) Vertical and straight with building lines (2) Level at a given elevation 5. Interest (attitude) toward successful completion of job

---

I. PREPARATION (OF THE LEARNER - MOTIVATION)

The sub-grade or base for a slab and beam foundation has been prepared, Lesson II-A-6(S). The next step is to erect (set) the foundation forms. There are two extremely important aspects to consider in slab form construction: (1) the forms must be set exact to line and grade, (2) the forms must hold to line and grade while the concrete is placed and cured.

Although this job may seem simple and some of the work semi-skilled, it is none the less important and must be done properly. Your evaluation for this task will be how accurately and productively you complete the work.

II. PRESENTATION (OF THE SKILLS)

STEPS	KEY POINTS (THINGS TO REMEMBER TO DO OR SAY)
1. Stretch Stringlines	1. On batterboard ledgers 2. To reference building lines a. Wall lines b. Corners c. Foundation "top of concrete" Note: If building plans call for brick ledge outside of building (wall) lines, include following - step #2
2. Mark Brick Ledge	1. On top of batterboard ledgers (all) 2. Outside (outboard) of building lines
A. Measure And Mark	1. Dimension as per foundation plans and details 2. Square with ledger top edge 3. Using pencil and tri-square
B. Cut Saw Kerf	1. At each mark 2. On top, back edge of ledger 3. At 45° angle a. In line with mark b. Approximately half-way through top edge of ledger
C. Set Tie Nails	1. On back side of each ledger 2. Directly below saw kerf 3. Approximately 1" deep 4. Use 6d finish nails
D. Restretch Stringlines	1. To brick ledge marks 2. To reference building foundation lines, corners
3. Set Tack Points	1. On grade 2. At all foundation corners
A. Set Up Tripod And Plumb-bob	1. Over stringline intersections 2. One-at-a-time 3. With legs straddled; free of stringlines 4. With head visually level 5. With plumb-bob suspended a. At stringline intersection b. To a point near ground
B. Mark Points	1. With 2" x 2" x 8" long hub stake a. Driven vertically into ground

- b. Head flush with ground
- c. At point below plumb-bob

2. With 8d finish nail
    - a. Driven vertically into stake
    - b. With 3/4" exposed
    - c. At exact point of plumb-bob

C. Stretch Stringlines

1. Taut!
2. Between all tack points
3. To mark foundation outline
4. At grade

Note: Stringlines on batterboards should be directly over stringlines at grade. Both mark foundation outline

4. Select Form Material

1. For quantity
    - a. As per foundation plans
    - b. Use standard lumber lengths
    - c. Total outside wall lengths
2. For size
    - a. As per foundation sections; details
    - b. Use standard 2" lumber
    - c. Width as per height of T.O.C. above grade (compacted), usually 2" x 6"
3. For quality
    - a. Use framing lumber
    - b. "S4S", "B and better"
    - c. Straight, clear
    - d. Ends square

5. Place Form Material

1. Around building perimeter
2. To check material quantities
3. For convenience during construction

6. Set First Form Board

1. Start at an outside corner
2. Edge of board on ground
3. Along and outside of lower stringline
4. Top inside edge along upper stringline

Note: If brick ledge is required tack 2" x 2" spacer blocks (1½") to top edge of form board for alignment purposes

5. End of board even with and against tack point
    - a. Set exact
    - b. For corner joint

A. Set 1st Stake

1. Outside and against form board
2. About 6" from end

3. Nearest foundation corner
4. In vertical position
5. Drive stake vertically into ground
    a. Carefully not to move form board or damage top of stake
    b. Until stake is firm in ground and level with top stringline

Note: If top of stake becomes damaged, allow sufficient stake above form board to cut off damaged area

B. Set 2nd Stake

1. At opposite end of form board
2. Outside and against form board
3. Half of stake width beyond end of form board
4. In vertical position
5. Drive stake vertically into ground as per 1st stake

C. Adjust Form Board Height

1. Raise/lower both ends at same time
2. Work board back and forth as necessary to:
    a. Seat in dirt properly
    b. To level
    c. To align with stringlines
    d. To position exact
3. Until top edge is level with top stringline
4. Check board level with carpenters level

D. Secure Form Board

1. To end stakes
2. With 12d duplex-head nails
    a. Two each stake
    b. From outside
3. While holding form board in position
    a. Back form board at stake
    b. Spike nails through stake into board

E. Add Additional Stakes

1. As needed
    a. On 4'-0 intervals approximately
    b. Along and outside of form board
2. Set and secure as previous form stakes

7. Set Subsequent Form Boards

1. Along entire foundation side
    a. To and beyond on outside corner

Note: Avoid cutting form boards where possible. It may be cleaned and reused later in the building frame

    b. To tack point on inside corner
2. With end butted to end of previous form board

3. At stake set half-way beyond previous board
4. Similar as per first form board
    a. Position in like manner
    b. Set stakes in like manner
    c. Align and level in like manner
    d. Secure in like manner
5. Measure and cut last form board to an inside foundation corner
    a. Length to exact tack point
    b. End cut square

8. Brace Form Work

1. With 2" x 4" braces approximately 4'-0 lg.
2. And 2" x 4" stakes approximately 1'-6" lg.
3. At each form stake

A. Position Braces

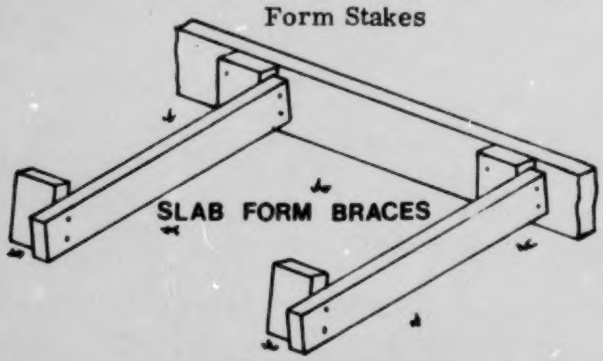
1. Outside of form board
2. 90° to form board
3. On edge
4. Adjacent form stake

B. Set Brace Stakes

1. Near outboard end of brace
2. Edge of stake against brace
3. Wide side parallel to form
4. Slant toward form slightly
5. Drive firmly into ground
6. Allow top 4'-5" of stake to stick up

C. Affix Braces To Form Stakes

1. With 16d duplex-head nails
2. Start nails (2) in brace
    a. 3/4" from end of brace
    b. 3/4" from each side of brace
3. Position Brace
    a. On edge
    b. End against form board
    c. Width against edges of stakes (form stake and brace stake)
4. Spike nails thru brace into form stake
    a. While backing stake
    b. Allow duplex-head to be exposed



Check Point:

Note: Check form board alignment against stringline at this point

D. Align Form Board

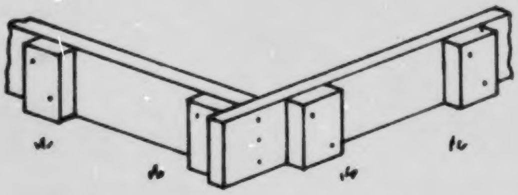
1. As necessary
2. By tapping gently at form stakes
    a. In-out-up-down
    b. To align top inside edge of form board with stringline (taut)
3. Tamp form stake if any adjustment is made

E. Affix Braces To Brace Stakes

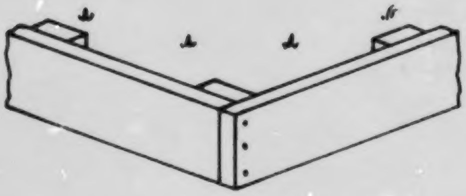
1. With (2) 16d duplex-head nails
2. While holding brace in place
3. While backing brace stake
4. Spike nails through brace into stake

9. Set Form Corner

1. For next foundation side
2. Similar as first form board
   - a. On edge
   - b. Inside edge aligned with stringline
3. End square and butted against last form board of previous foundation side
4. Set stakes, level form board and secure to stakes similar as step #6
5. Nail outside foundation form corner
   - a. With 16d duplex-head nails (3)
   - b. Thru outside form board
   - c. Into end grain of inside form board
   - d. Vertically in line
   - e. Centered in end grain
6. Nail inside foundation corner
   - a. With 16d common nails (3)
   - b. Thru inside form board
   - c. Into end grain of outside form board
   - d. Vertically in line
   - e. Centered in end grain



OUTSIDE CORNER



INSIDE CORNER

Note: Continue setting forms until all sides are complete

10. Lay Out Foundation Beams

1. Using steel measuring tapes
2. Measure from building corners
   - a. To locate centerlines of inside beams
   - b. Dimensions as per foundation plans
3. Measure beam widths
   - a. As per foundation sections; details
   - b. Dimensions to straddle centerlines on inside beams
4. Use building lines as guide for outside beams
5. Set stakes and stringlines
   - a. For excavation guides
   - b. Where necessary

Check Point: Double check excavation layout and dimensions before any excavation commences

11. Excavate Foundation Beams

1. With hand tools
2. Dig center of trench first
   - a. Entire length of beam
   - b. With shovels, picks as necessary

3. Check depth of trench regularly
    a. With yardstick or folding rule
    b. Against building stringline (T.O.C.)
4. Trim trench walls
    a. To correct width
    b. To be straight
    c. To be vertical
    d. Perimeter walls plumb with inside of form boards
5. Square corners
6. Cut angle of repose
    a. Where called for
    b. As per foundation sections; details
7. Clean debris from trenches
    a. All grass, roots, sticks
    b. Any foreign matter
8. Level and compact trench bottoms
    a. With hoe, rake
    b. With hand tamper
9. Dispose excavated material
    a. Outside and against foundation forms
    b. Tamp to reinforce forms
    c. Excess to be removed/redistributed later

Notes:
1. Exercise safety, proper technique when using hand digging tools
2. Do not overcut width of beam trenches
3. Refer to Plumbing Basic Course Outline for underground plumbing location, excavation, installation, backfill, and compaction

III. APPLICATION (PRACTICE BY LEARNER UNDER CLOSE SUPERVISION)

1. Preview specific job; tasks
2. Students become familiar with job, task sheets
3. Assign students job tasks, responsibilities
4. Discuss job procedures, methods - emphasize keypoints, check points, job safety
5. Review measuring devices - how to use; how to read
6. Practice setting a form board to "a line and a grade" and bracing the board

IV. VERIFICATION AND/OR EVALUATION (CHECK ON STUDENT'S ABILITY)

1. Set tack points for all building corners
2. Set and brace forms to line and grade
3. Excavate for foundation beams

V. SUMMARY (TELL THE STEPS ON PROCEDURE AS TO WHAT, HOW, AND WHY. REVIEW CHECKING STANDARDS. THIS SUMMARY MAY BE GIVEN AT ANY PLACE IN THE LESSON THE TEACHER FEELS WILL BE PROFITABLE TO THE STUDENTS.)

1. Stretch stringlines on batterboards to reference foundation lines; top of concrete elevation
   - a. To building wall lines - wood frame building
   - b. To brick ledge lines - brick or brick veneer building
2. Set foundation corner locations on tack points at grade
   - a. Use tripod and plumb bob to transfer (drop) corner locations
   - b. Mark with 2" x 2" stake flush in ground; with 8d finish nail at exact point in stake
3. Stretch second stringline between tack points on grade
4. Select form material
   - a. For size - use standard lengths, widths, thickness as per plans and details; allow corners to overlapp where possible; cut to length only when necessary
   - b. For Quality - use framing lumber, S4S, "B" and better. Select clear, straight lumber. May be cleaned and reused in building frame
5. Set forms
   - a. Outside and along stringlines
   - b. To line; to grade - use 1½" spacer blocks on top edge of form board if brick ledge is incorporated
   - c. Start at tack point of outside corner; work around
6. Secure forms
   - a. With 2" x 4" form stakes - set vertically in ground firm and flush with outside of forms. One stake near ends at corners; one stake stradding each form joint, with additional stakes on 4'-0 intervals
   - b. With 16d duplex-head nails - (2) each stake, spike through outside of stakes into form boards while backing form board at stake
7. Brace forms
   - a. With 2" x 4" braces approximately 4'-0 lg. at each form stake. Position on edge next to form stakes and extend out 90° from forms.
   - b. With 2" x 4" x 18" lg. brace stake set firm in ground; edge of stake flush to side of brace on outboard end

c. With 16d duplex-head nails - spike thru form brace into form stake; check form alignment; spike thru form brace into brace stake

8. Excavate for foundation beams
   a. Lay out and mark beam locations with stringlines
   b. Excavate with hand tools exercising care not to overcut width or damage trench walls
   c. Remove excavated soil - place outside and against forms; tamp lightly to reinforce forms
   d. Trim trench walls to be vertical; corners to be square
   e. Remove all debris from trenches and tamp trench bottoms flat and smooth and to correct depth

---

SUGGESTED READING FOR STUDENTS:

Modern Carpentry, Unit 6, pp 87-110
Fundamentals of Carpentry, pp 64086

The Next Lesson Is: II-B-2(S) "Erect Forms For Foundation Footings - Footing And Wall Foundation"

II-B-1(J)

JOB SHEET
IN
SETTING CONCRETE FORMS

NAME OF JOB: Erect Forms For Slab And Beam Foundation

MATERIALS: 2" x 6", or 2" x 8" form boards, 12d duplex head nails, 8d finish nails, 2" x 4" x 18" lg. form stakes, 2" x 4" x 3'-0 lg. form braces, 2" x 2" x 8" lg. hub stakes, nylon cord

TOOLS AND EQUIPMENT: 6" folding rule or tape measure, carpenter's level, hand saw (cross cut), sledge hammer, claw hammer (14oz.), plumb bob, tripod

GENERAL INSTRUCTIONS: The sub-grade has been prepared and is ready to receive the forms. The two important aspects of form construction are: (1) the forms be set to line and grade; and (2) the forms hold the concrete to line and grade during placement and curing.

PROCEDURE AND/OR TASK:

II-B-1(TS)	Establish Foundation Lines
II-B-1a(TS)	Select And Position Form Material
II-B-1b(TS)	Set And Brace Form Boards

CHECK POINTS: Check each form board for alignment (line control) and level (grade control) before securing to form stakes

Check all corners; joints to be flush and tight before securing to stakes

TASK SHEET

II-B-1(TS)

TASK: Establish Foundation Lines

JOB: Erect Forms For Slab And Beam Foundation

TRADE: Building Trades

TOOLS AND MATERIALS: 6' folding rule, claw hammer, 2" x 2" x 8" lg. stakes, tri-square, 3 lb. engineer's hammer, 8d finish nails, hand saw (cross cut), nylon cord, plumb bob, tripod

TASK BREAKDOWN:

STEPS	KEY POINTS
1. Mark Brick Ledge (Optional) (For Brick Veneer Construction)	1. On batter board ledgers (all) 2. Outside (outboard) of building lines 3. Dimensions as per plans and details 4. Cut 45° kerf and set tie-nail on back side as per other ledger marks
2. Stretch String Lines	1. Taut 2. To reference building foundation lines
3. Set Tack Points	1. At all foundation corners 2. With 2" x 2" stake driven flush in ground 3. With 8d finish nail set vertical in stake — 3/4" exposed at exact spot 4. Use plumb bob suspended at intersections of string lines
4. Stretch 2nd String Line	1. Taut 2. From tack point to tack point 3. To form foundation outline on grade

TASK SHEET

II-B-1a(TS)

TASK: Select And Position Form Material

JOB: Erect Forms For Slab And Beam Foundation

TRADE: Building Trades

TOOLS AND MATERIALS: Dimension lumber as required

TASK BREAKDOWN:

STEPS	KEY POINTS
1. Select Form Boards	1. For quality – use S4S, B or better, straight, clear of flaws, ends square 2. For size – use standard 2" lumber, width as required – usually 6" or 8" 3. For quantity – as per foundation plans use standard lengths where possible
2. Select Form Stakes And Braces	1. Straight, strong, clear of flaws 2. Lengths and quantities appropriate for type soil conditions
3. Position Form Material	1. Around building perimeter 2. To check material lengths; quantities 3. For convenience during construction

TASK SHEET

II-B-1b(TS)

TASK: Set And Brace Form Boards

JOB: Erect Forms For Slab And Beam Foundation

TRADE: Building Trades

TOOLS AND MATERIALS: Sledge hammer, 2" x 6" or 2" x 8" form boards, 2" x 4" form stakes, 12d duplex-head nails, claw hammer, 2" x 4" form braces, carpenter's level

TASK BREAKDOWN:

STEPS	KEY POINTS
1. Position First Form Board	1. On edge on ground
	2. End flush with tack point
	3. Inside face along side and touching string lines (top and bottom)
2. Set First Stake	1. Outside and against form board
	2. Width flush to form board
	3. Edge flush to end of form board
	4. Drive stake vertically into ground until held firm
3. Set Second Stake	1. At opposite end of form board
	2. Outside and flush against form board as per first stake
	3. Half of stake width beyond end of form board if form continues in same direction
	4. Drive stake vertically into ground as per 1st stake
4. Adjust Board Height	1. Raise/lower both ends at same time
	2. Work board back and forth as necessary to: a. seat in the dirt b. align upper edge with string line c. level in exact position
	3. Check board level with carpenter's level
5. Secure Form Board	1. To end stakes
	2. While holding board in position
	3. With (2) 12d duplex-head nails each stake
	4. Spike nails through stakes into board

STEPS		KEY POINTS
	5.	While backing board at stakes
6. Add Intermediate Stakes	1.	As needed
	2.	On 4'-0 intervals approximately
	3.	Set and secure as previous form stakes
7. Set Subsequent Form Boards	1.	Around entire foundation
	2.	Similar as first form board
	3.	With ends butted to end of previous form board
	4.	With outside corner boards overlapping
	5.	With inside corner boards cut and fitted
8. Brace Forms	1.	As required
	2.	Position braces 90° out from form boards on edge and adjacent to form stakes
	3.	Set brace stakes firmly in ground near outboard end of brace with edge adjacent the brace and the top of the stake slanted toward form slightly
	4.	Secure brace to stakes with (2) 12d duplex-head nails while backing stakes

INSTRUCTOR'S PLAN
MANIPULATIVE LESSON

II-B-2(S)

TASK:	Erect Forms For Foundation Footings - Footing and Wall Foundation
AIM:	The students will be able to erect/construct forms for footings, footing and wall foundations, according to blueprints and specifications while exercising sound and acceptable building practices and procedures.
TOOLS AND EQUIPMENT:	Trenching machine and/or backhoe (optional), steel measuring tapes, sledge hammers, picks, shovels (sharp shooters and round nose), rakes, wheelbarrows, plumb-bobs, carpenter's level, claw hammers, framing square, hand saw
MATERIALS:	Framing lumber (2" x 8", 10", 12" or as required for footing thickness, length), 2" x 4" braces, 2" x 4" spacers, 2" x 4" stakes as required, nylon string, 12d, 16d common and duplex-head nails, 8d finish nails
TEACHING AIDS:	Project blueprints and specifications, pencil, and note pad
REFERENCES:	Modern Carpentry, pp. 90-96 Fundamentals of Carpentry, pp. 54-64, 71-86 Concrete Form Construction, pp. 78-84
PREREQUISITE EXPERIENCE OF THE LEARNER:	The student must have successfully completed previous lessons II-A-2(I), "Blueprint Reading"; II-A-7(I), "Layout Building Lines"; II-B-1(I), "Soil Preparation and Excavation"; II-B-2(I) "Concrete Form Construction"
CHECKING STANDARDS:	1. Follows proper building procedures, techniques 2. Proficient in use of tools, equipment 3. Efficient use of time, materials 4. Acceptable degree of accuracy in layout, excavation, construction, and/or erection of forms 5. Interest (attitude) toward successful completion of job

---

I. PREPARATION (OF THE LEARNER - MOTIVATION)

In previous lessons the building site was cleared; the building location scraped (cut or filled) to grade removing grass, roots, and other debris, building lines staked, and batterboards erected. It is time to excavate and construct foundation forms for the footing and wall type foundation.

The size and depth of footing and wall foundations are determined by the designer or architect based on the building loads; type soil and load bearing qualities; and environmental conditions such as moisture, climate, and frost line. The extent of excavation, however, is generally left up to the builder: "whatever is necessary to construct the forms safely and efficiently".

Shallow footings and walls generally require no more room than necessary to properly place the footing forms. In deeper excavations, work room must be allowed outside the foundation walls to properly construct and erect the forms. A space of 2'-0" either side of the wall is usually sufficient. In deep excavations where soil type warrants, the correct angle of repose on excavation walls must also be considered to prevent wall cave-ins.

Most footing and wall form construction is not difficult if a few rules are observed and adhered to. Pay attention to excavation details! Excavation should be the correct depth and width to allow sufficient room for form construction; the bottom should be clean, flat, and level as possible. The top of the footing forms must be the correct elevation and level; and forms sufficiently braced to hold the plastic cement during placement and curing.

II. PRESENTATION (OF THE SKILLS)

STEPS	KEY POINTS (THINGS TO REMEMBER TO DO OR SAY)
1. Study Foundation Plans, Sections, Details	1. To become familiar with job requirements a. location of footings; walls b. size of footings; walls 2. To establish extent of excavation a. where to excavate b. depth of excavation c. width of excavation d. datum point(s) 3. To plan form construction a. material requirements b. bracing requirements
2. Lay Out Excavation	1. Use steel measuring tapes 2. Measure from building corners a. dimensions as per foundation plans b. to centers of inside foundation walls 3. Measure excavation widths a. as established in step #1 b. dimension to straddle foundation walls

4. Set stakes and stringlines at grade
    a. along points measured
    b. for excavation guides

Check Point:

Double check excavation layout and dimensions before any excavation commences

3. Excavate

1. For foundation footings and walls
2. With trenching machine and/or backhoe where feasible
    a. consult with machine operator before excavation commences
    b. oversee and advise operator during excavation
    c. assist operator upon request

NOTE: Exercise extreme caution in area where heavy equipment is operating

3. With hand tools where required
    a. trim walls; square corners
    b. clean debris from trenches
    c. level and compact trench bottoms
    d. any other special excavation
4. Check excavation depth frequently
    a. as excavation approaches required depth
    b. with vertical measurements
    c. from stringline stretched between batterboards - reference T. O. C.
5. Store excavated earth
    a. outside of building lines
    b. in area(s) not to interfere with foundation construction
    c. to be used later as backfill

Check Point:

Double check excavations to be correct width, depth, clean, tamped flat and smooth. Check angle of repose - walls

4. Establish Building Corners, Building Lines

1. In excavation bottoms
2. With plumb-bob
    a. re-establish building lines on batterboards

    b. suspend plumb-bob
    c. at intersection of building lines
    d. to bottom of excavation
3. With hub stakes (2" x 2" x 16" lg.)
    a. set vertically in ground
    b. at point of plumb-bob
    c. top of stake level with top of footing

NOTE: Set elevation with builder's transit level and surveyor's rod

    1. Set up and level instrument centrally located inside building lines
    2. Set rod target on "H.I. above T.O.C." plus "foundation wall height"
    3. Position rod vertically on stake
    4. Shoot rod - drive stake
    5. Until rod target and instrument horizontal cross-hair align

4. With 8d finish nails
    a. set vertically in top of hub
    b. at exact point of plumb-bob
    c. with head exposed 3/4"
5. With stringlines
    a. stretched taut
    b. between nails in corner hubs
    c. flush to top of hubs

Check Point:

Double check all corner hubs location and elevation

5. Set Grade Stakes

1. At regular intervals
2. Along lower stringline

NOTE: At least (2) stakes, each form board length

3. In vertical position
    a. side of stake flush to inside of string
    b. top of stake flush to stringline
4. Firmly in ground

6. Cut and Set Form Spacers

1. From 2" x 4" or 2" x 6" material
    a. measure length of spacers
    b. mark and cut to length square

2. Mark dimension footing extends outside of foundation wall
    a. square on one edge of spacers
    b. from one end of spacer only
3. Position spacers (one-at-a-time)
    a. on edge with marked line up
    b. against edge of grade stake
    c. measured distance to the outside
    d. edge of spacer flush with top of stake
    e. marked line on stringline
4. Spike 12d duplex-head nail
    a. through spacer into stake
    b. approximately 3/4" from top edge
    c. while bucking (backing) stake
5. Level spacer with carpenter's level
6. Spike second 12d duplex-head nail
    a. through spacer into stake
    b. approximately 3/4" from bottom edge
    c. while bucking (backing) stake

7. Set Outside Forms

1. Start at one corner
2. Position 1st board
    a. on edge
    b. corner end extending beyond foundation corner
    c. inside face against ends of form spacers (at least two spacers)
3. Work form board back and forth to seat
    a. top of board flush with end of spacers
    b. inside face butted to end of spacers

Check Point:

Check form board top edge to be level. Use carpenter's level:
    a. across grade stakes to form board
    b. along top of form board

A. Set Form Board Stakes

1. Similar as previous lesson II-B-1(S)
2. Set 1st stake

   - a. about 6" from corner end
   - b. in vertical position
   - c. side of stake flush with outside of form
   - d. drive firm into ground
   - e. head flush with top of form board

3. Set 2nd stake
   - a. at opposite end of form board
   - b. half of stake width beyond end of board
   - c. drive vertically into ground as per 1st stake
4. Set intermediate stakes
   - a. as needed
   - b. on 4'-0" intervals approximately
   - c. similar as first stakes

Check Point:

Check board elevation and level with transit and rod as in step #4, this lesson

B. Secure Form Boards

1. To end stakes first
   - a. while holding board in position
   - b. while bucking (backing) form board
   - c. spike (1) 12d duplex-head nail each end
   - d. through stake into form board
2. To all stakes
   - a. with (2) each, 12d duplex-head nails
   - b. spike thru stake into form as per end stakes

NOTE: Continue setting form boards butted end-to-end; aligned and leveled as above; with corners overlapping until the outside of the footing form is complete

3. At corners
   - a. with (3) 12d duplex-head nails
   - b. thru outside form board overlapping
   - c. centered in end grain of form board abutting

8. Set Inside Forms For Footing

1. Start at corner
2. Position two form boards
    - a. one each direction
    - b. on edge
    - c. against inside ends of spacers
    - d. with corner ends butted flush
3. Work back and forth to level and seat
    - a. top flush with tops of spacers
    - b. inside face against ends of spacers
    - c. corners butted flush

Check Point:

Check with carpenter's level
- a. across tops of form boards
- b. along top of inside form boards

4. Set stakes similar as per outside stakes
    - a. one stake flush in corner
    - b. spaced approximate 4'-0" intervals
    - c. vertical and flush with top of form
    - d. one stake straddle each form board joint
5. Secure form boards similar as per outside forms
    - a. each end first
    - b. middle second
    - c. corners last

NOTE: Use 12d commons for inside corners. Set heads flush to inside form

9. Clean Form Bottom

1. Remove corner hubs, grade stakes, and spacers
2. Fill holes left by stakes
3. Clean and level form bottom
    - a. scrape high spots
    - b. fill low spots
    - c. rake to level
    - d. remove debris; excess dirt
    - e. tamp firm and flat

NOTE: At this point reinforcement bar is set, the concrete placed, and key-ways or tie rods inserted in plastic concrete. After the concrete has set, remove the keyway and forms

III. APPLICATION (PRACTICE BY LEARNER UNDER CLOSE SUPERVISION)

1. Students become familiar with job, tasks.

2. Students practice setting up, leveling transit or builder's level.

3. Students practice setting stakes to a given elevation using level instrument and surveyor's rod.

4. Students practice setting form boards to a given line; grade.

5. Preview specific job at hand.

6. Make student assignments.

IV. VERIFICATION AND/OR EVALUATION (CHECK ON STUDENT'S ABILITY)

1. Perform any/all special excavation in preparation for erecting footing and wall foundation forms.

2. Re-establish building lines; corners in excavation.

3. Erect/construct footing forms to line; to grade as per blueprints and specifications.

V. SUMMARY (TELL THE STEPS ON PROCEDURE AS TO WHAT, HOW, AND WHY. REVIEW CHECKING STANDARDS. THIS SUMMARY MAY BE GIVEN AT ANY PLACE IN THE LESSON THE TEACHER FEELS WILL BE PROFITABLE TO THE STUDENTS.)

Study foundation plans and details to become familiar with the location and size of all foundation footings and walls. Establish the extent of excavation required from the depth and size of the foundation footings and walls. Note elevations!

Lay out excavation as per foundation plans. Use steel measuring tapes; measure from building lines, corners previously located; excavation widths to straddle foundation walls.

Oversee major excavation advising/assisting when required. Exercise extreme caution while working in areas where heavy equipment is operating. Perform all necessary special excavation: trim walls; square corners; rake trench bottoms to clean of debris and level; tamp to compact.

Establish building lines in excavation bottom with:
plumb-bob suspended at intersections of stringlines on batterboards,
hub stakes set vertically below plumb-bob at "top of footing" elevation,
8d finish nail set vertically in top of hubs at exact point of plumb-bob, with 3/4" exposed,
stringlines stretched between nails at top of hubs.

Set grade stakes along stringlines at regular intervals with sides flush to inside of stringline and tops flush to stringline. Set vertical!

Cut form spacers, mark, and secure to edge of stakes; flush with top of stakes and level with carpenter's level.

Set outside forms -- on edge, top flush with top of spacer; inside face against ends of spacers; corner end overlapping; form joints butted flush. Work back and forth to seat properly.

Set form stakes at approximate 4'-0" intervals in vertical position flush to the outside of form. Drive stakes flush with top of form. The last stake of each form board should extend half of stake width beyond end of board to seal form joint.

Check level and elevation with transit level and surveyor's rod.
Transit set up and leveled in centrally located position inside building lines.
Rod target set on "H. I. above T. O. C." plus "height of foundation wall".
Position rod on top of form in vertical position.
Shoot rod with instrument -- rod target and horizontal cross-hair to agree!

Secure forms with 12d duplex-head nail through stakes into form while holding form in position and bucking form opposite stakes.

Set inside forms -- similar as outside forms: on edge; against and flush with spacers; ends butted squarely, corner butted flush.

Check level with carpenter's level -- across forms; along top of inside form.

Set stakes and secure form similar as outside form.

Remove stakes and spacers; fill holes; clean, rake, level, and tamp form bottom.

SUGGESTED READING FOR STUDENTS:

Modern Carpentry, pp. 89-96
Fundamentals of Carpentry, pp. 71-84

The Next Lesson Is: II-B-3(S), "Erect Forms for Foundation Walls - Footing and Wall Foundations"

II-B-2(J)

JOB SHEET
IN
SETTING CONCRETE FORMS

NAME OF JOB: Erect Forms For Foundation Footings

MATERIAL: 2" x form boards, 2" x 4" spacer stakes, 8d finish nails, nylon cord, 2" x 4" form stakes, 1" x 6" spacers, 12d duplex-head nails, 2" x 2" hub stakes, 16d duplex-head and common nails

TOOLS AND EQUIPMENT: Builder's level, claw hammer, carpenter's level, tripod, sledge hammer, tri-square, plumb bob, engineer's hammer, 6' folding rule, level rod, hand saw(cross cut), 100' steel measuring tape

GENERAL INSTRUCTIONS: Forms for most footings are easily constructed if careful attention is paid to a few details. Locate the corner hubs accurately in the excavation and set the tops of the hubs precisely at the same elevation specified for "Top of Concrete Footings". The rest is a matter of keeping checks on levels and alignments as form boards are set.

PROCEDURE AND/OR TASK:

II-B-2(TS)	Locate Building Lines In Excavation

CHECK POINTS: Check corner hubs location and elevation

II-B-2a(TS)	Install Spacer Stakes And Form Spacers
II-B-2b(TS)	Set Outside And Inside Form Boards

CHECK POINTS: Check each form board as it is set for level, alignment, elevation

TASK SHEET

II-B-2(TS)

TASK: Locate Building Lines In Excavation

JOB: Erect Forms For Foundation Footings

TRADE: Building Trades

TOOLS AND MATERIALS: Builder's level, level rod w/target, claw hammer, tripod, plumb bob, 2" x 2" x 18" lg. stakes, nylon cord, 8d finish nails, 3 lb. engineer's hammer

TASK BREAKDOWN:

STEPS	KEY POINTS
1. Stretch String Lines	1. Taut 2. On batter boards 3. To reference building line
2. Suspend Plumb Bob	1. At intersections of string lines 2. One-at-a-time 3. To locate building corners 4. In excavation
3. Position Corner Hub	1. 2" x 2" x 18" lg. stake one-at-a-time 2. In vertical position 3. Directly below point of plumb bob 4. At bottom of excavation
4. Set Top of Corner Hubs to "Top of Concrete" Footing Elevation	1. Set up and level instrument, determine H. I. 2. Calculate difference in H. I., and T. O. C. footing 3. Set "difference" reading on level rod with target 4. Position rod vertically on stake, shoot rod, drive stake alternately until rod target and instrument cross-hair align Note: Exercise care not to damage top of stake
5. Set Tack Point	1. In top of hub stake 2. With 8d finish nail set vertically 3. At exact point of plumb bob
6. Stretch Second String Line	1. Taut 2. Between all corner hubs in excavation 3. Flush to tops of hub stakes

STEPS	KEY POINTS
	Note: String line references building lines; T. O. C. of foundation footing
CHECK POINTS:	Check: Corner hubs tack positions to be exact using plumb bob Check corner hubs elevations to be exact use level instrument and rod

TASK SHEET

II-B-2a(TS)

TASK: Install Spacer Stakes And Form Spacers

JOB: Erect Forms For Foundation Footings

TRADE: Building Trades

TOOLS AND MATERIALS: Claw hammer, 6' folding rule, 2" x 4" stakes as required, tri-square, sledge hammer, 1" x 6" spacers as required, hand saw, carpenter's level, 6 or 8d duplex-head nails

TASK BREAKDOWN:

STEPS		KEY POINTS
1. Set Spacer Stakes	1.	At least (2) stakes each form board length
	2.	At regular intervals along lower string line
	3.	In vertical position with side of stake flush to inside of string line
	4.	Drive stakes firmly into ground until top of stake is flush with string line
	Note:	Do not damage top of stake
2. Cut Spacers And Mark For Installation	1.	Use 1" x 6" material
	2.	Measure length of spacers (width of footing)
	3.	Mark and cut to length square
	4.	Mark "length foundation footing extends outside building line" square on edge of spacer board from one end
3. Position Spacers	1.	Against side of stake one-at-a-time
	2.	Flush with top of stake
	3.	With mark on string line
	4.	With footing offset dimension outside of string line
4. Secure Spacers	1.	With spacer top edge flush to top of stake, string line
	2.	With mark aligned with string line
	3.	Spike 8d duplex-head nail a. one inch down from top edge b. through spacer into center of stake c. while backing stake
	4.	Level spacer using carpenter's level
	5.	Spike second nail one inch up from bottom of spacer similar as first nail

TASK SHEET

II-B-2b(TS)

TASK: Set Outside And Inside Form Boards

JOB: Erect Forms For Foundation Footings

TRADE: Building Trades

TOOLS AND MATERIALS: Claw hammer, 2" form material, sledge hammer, 2" x 4" form stakes, carpenter's level, 12d duplex-head nails

TASK BREAKDOWN:

STEPS	KEY POINTS
1. Select Form Board Materials	1. To be straight, strong, good quality 2. Width appropriate for footing thickness
2. Position Outside Form Boards	1. One-at-a-time 2. Start at one corner 3. Position board on edge with inside face against end of form spacers Note: Outside corners to be butted and overlapped 4. Work form board back and forth to seat top of board flush until tops of spacers
CHECK POINTS:	Check: Top of form board to be level — use carpenter's level Top of form board elevation, each end — use builder's level and level rod
3. Set Form Stakes (2)	1. Side flush to outside of form board 2. At or near each end 3. Similar as previous task II-B-1b(TS)
4. Secure Form Board To Stakes	1. While holding form board in position 2. While backing form board 3. Similar as previous task II-B-1b(TS)
5. Add Intermediate Stakes	1. As required 2. On approximate 4'-0 intervals 3. Similar as previous task II-B-1b(TS)
6. Set Subsequent Form Boards	1. Around entire footing O. D. 2. With ends butted to previous form board 3. With corners butted and overlapping 4. As per steps #1 through #5 above

STEPS	KEY POINTS
7. Position Inside Form Boards	1. Start in corner
	2. Position (2) boards, (1) each direction
	3. On edge
	4. With sides flush against ends of spacers
	5. With top edge flush with tops of spacers
	Note: Work board back and forth to seat top edge flush with top of spacers
	6. With ends butted flush at corner
CHECK POINTS:	Check: Top of form board to be level along its length Top of form board to be level with outside form board (across boards). Use carpenter's level
8. Set Form Stakes	1. As required on inside
	2. One stake in corner flush with both corner boards
	3. At approximately 4'-0 intervals
	4. One stake to straddle each form board joint
	5. Set stakes vertical; flush with side of form board; level with top of form board
9. Secure Form Boards To Stake	1. While holding form board in position (level; correct elevation)
	2. While backing form board
	3. Spike (2) 16d duplex-head nails through into form board
10. Set Subsequent Inside Form Boards	1. Around entire footing I. D.
	2. One board at-a-time
	3. Butted and aligned to previous boards
	4. Leveled and secured similar as previous boards
	Note: Last board approaching an inside corner must be measured and cut square to provide a flush butt joint on inside corners
11. Secure Form Corners	1. With 16d duplex-head nails, outside corners
	2. With 16d common nails, inside corners

STEPS	KEY POINTS
	3. Spike through board overlapping
	4. Into end grain, board abutting
	5. 2 - 3 nails each corner joint
CHECK POINT:	Check: Form dimensions (inside) width of footings depth of footings lengths offsets (outside of building line) Form level and alignment Form elevation
12. Remove Erection Guides And Clean Form Bottom	1. Remove string lines, corner hubs, spacers and spacer stakes 2. Fill, pack holes made by stakes 3. Rake to clean and level removing debris, excess dirt 4. Tamp to pack flat

INSTRUCTOR'S PLAN
MANIPULATIVE LESSON

II-B-3(S)

TASK: Erect Forms For Foundation Walls - Footing and Wall Foundations

AIM: The students will be able to erect/construct foundation wall forms according to blueprints and specifications following acceptable building practices and procedures.

TOOLS AND EQUIPMENT: Hammers (claw and sledge), saws (hand and power), steel measuring tapes, folding rules, chalk line, squares (framing and tri), carpenter's level

MATERIALS: Plywood form panels as calculated and estimated from blueprints and specifications; framing lumber as required for plates, vertical supports, walers, braces, and stakes; form ties as required; nails, 6d commons, 12d commons, 16d duplex-head

TEACHING AIDS: Project blueprints and specifications; note pads, pencils

REFERENCES:
Modern Carpentry, pp. 90-96
Fundamentals of Carpentry, pp. 54-64, 71-86
Concrete Form Construction, pp. 78-84

PREREQUISITE EXPERIENCE OF THE LEARNER: The student must have successfully completed

CHECKING STANDARDS:

1. Efficient use of time; materials
2. Proficient in use of tools; equipment
3. Follows sound building procedures; practices
4. Acceptable degree of accuracy in layout construction and erection of forms
5. Sincere interest learning the building trades

I. PREPARATION (OF THE LEARNER - MOTIVATION)

Residential contractors who build large numbers of homes plan and use repeatedly the same or similar floor plan. With a little forethought, rooms can be rearranged and building styles changed to conceal the fact that several residences in the same block, certainly in the same neighborhood, share a common foundation plan.

This is done in the interest of economy and as a time-saving factor. Forms may be prefabricated and used repeatedly with a considerable savings of time and material.

I. PREPARATION (CON'T)

This practice has given rise to numerous commercial form systems which can either be purchased or rented, and to an increasing specialization in the building trades; the foundation contractor.

Foundation contractors work with specialized crews who erect forms, set the reinforcement, place and work the plastic concrete, set the anchoring devices, and finish the concrete surfaces. In addition, these crews remove, clean, and maintain these prefab forms for repeated use. Although this specialization is gaining in popularity, each building trades student should become familiar with concrete form construction for he/she may be called on at any time to construct and erect some type of concrete form. And who knows, maybe it will become your specialty.

One must keep in mind during form construction that form surfaces must be smooth, defect free, and properly aligned. Joints must be tight to prevent loss of cement paste and the forms must be strong and well braced to resist the lateral loads created by plastic concrete.

II. PRESENTATION (OF THE SKILLS)

STEPS	KEY POINTS (THINGS TO REMEMBER TO DO OR SAY)
1. Study Foundation Plans, Details	1. To become familiar with job requirements a. height of foundation walls b. length of foundation walls c. thickness of foundation walls 2. To calculate form requirements a. cubic feet of concrete per lineal foot of foundation wall b. weight of plastic concrete per lineal foot of foundation wall c. lateral pressures exerted NOTE: Refer to Lesson II-B-1(I), "Concrete Form Construction" 3. To design adequate forms; braces a. determine size;thickness of form panels b. determine spacing of vertical supports c. determine walers, if necessary, and spacing d. determine spreaders, their location and spacing

4. Compose a bill of material
   a. number of pieces
   b. size of pieces
   c. type material

2. Construct Form Panels

1. From standard size plywood sheets
   a. thickness as per load requirements (see design factors, lesson II-B-1(I)
   b. length and height determined by wall lengths; heights

EXAMPLE:

8'-0 foundation wall turn plywood on end to form panels 8'-0 high and 4'-0 wide
4'-0 foundation wall turn plywood on side to form panels 4'-0 high and 8'-0 long

NOTE: If panels are to be permanent, used several times, cut to size. If panels are used one time, cleaned and re-used as a sub-floor or sheathing, refrain from cutting if possible

2. From 2" x 4" backing supports
   a. cut to precise length
   b. cut square

A. Nail Sole Plate

1. To back side of form panel
   a. at base
   b. edge of sole against panel
   c. ends; bottom flush
2. With 6d common nail
   a. approximately 3/4" from base of panel
   b. spaced on 10" intervals approximately
3. Spike thru panel into sole
   a. straight
   b. head flush to panel surface

B. Nail Vertical Supports

1. Cut to length squarely
2. To back side of form panel
   a. on edge
   b. ends butted flush against sole
   c. first and last support flush with sides of panel

- d. intermediate supports equally spaced O. C. as per design factor, lesson II-B-1(I)

3. With 6d common nails
4. Spike thru panel similar as step #2A above

C. Nail Top Plate

1. To back side of form panel
2. Similar as bottom plate
    - a. edge flush with top of panel
    - b. ends flush with end of panel

D. Nail Plates To Supports

1. With 12 or 16d commons - (2) each joint
2. Spike thru plates into supports - top and bottom
    - a. 3/4" from each edge of plate
    - b. centered in end grain of supports
    - c. straight and flush to head

NOTE: For convenience and economy, some contractors prefer to check dimensions on the site and prefab the panels in their shop and deliver to the site fabricated

3. Establish Building Corners, Building Lines

1. On foundation footing swept clean
2. With plumb-bob
    - a. suspend at insection of stringlines
    - b. stretched taut on batterboards
3. With chalk
    - a. mark exact spots
    - b. below point of plumb-bob
4. With chalkline
    - a. stretched between corners
    - b. pop a chalk line
    - c. on top of foundation footing
    - d. for each foundation wall

4. Position Outside Form Panels

1. One-at-a-time; one wall at-a-time
2. Start at one corner
    - a. with smooth (panel) side in
    - b. with supports to outside
3. With panel base to chalk line on footing
4. With panel top to stringline on batterboards
5. With panel sides butted and aligned flush

NOTE: On outside form corners one panel may overlap. On inside form corners, filler panels should be constructed after all other panels are in place. This permits more accurate measurements; hence more accurate fits

6. Nail together with 16d duplex-head nails
   - a. thru vertical supports each side
   - b. on backside of panels
   - c. spaced 10-12" alternately on opposite sides
7. Nail outside corners
   - a. thru back of panel overlapping
   - b. into vertical support of panel forming corner

NOTE: For more permanent forms, drilled holes and bolts may replace nails

5. Brace Form Panels

1. While holding in place
   - a. base to chalkline on foundation footing
   - b. top to stringline on batterboard
2. On 4'-0 intervals for walls 8'-0 or less in height
3. With knee braces approximately 45° where possible

A. Position 1st Brace

1. Horizontal member on edge
   - a. extending out 90° from back of form
   - b. one end on top of sole against back of panel
   - c. side next to vertical support
   - d. opposite end blocked to level
2. Inclined member on edge
   - a. position at proper angle
   - b. on top of horizontal brace
   - c. against back of panel
   - d. against vertical brace

NOTE: If inclined member is less than stud length and cannot be reused as such the ends may be beveled to fit flush against back of panel and top of horizontal brace

3. Set stake
    a. at junction of horizontal and inclined braces
    b. side flush to side of brace members
    c. vertically in ground-firm
    d. with ample projection for nailing to braces

B. Secure Brace

1. To panel vertical support
    a. with 16d duplex-head nails
    b. while holding panel in place
    c. while holding brace in place
    d. spike thru brace into vertical support
    e. one (1) nail each brace member
2. To brace stake
    a. with 16d duplex-head nails
    b. while holding panel in place
    c. while backing brace member
    d. spike thru stake into brace
    e. one (1) nail each member

NOTE: Position and secure all braces in a similar manner. Space first braces out to position and hold long wall section forms - fill-in with intermediate braces to support forms

6. Install Wales and Ties

1. To outside wall forms
2. As required
    a. according to form calculations; spacing
    b. to resist lateral loads of plastic concrete

A. Install Wales

1. Select good quality, straight material
2. Position horizontally outside of vertical supports of panel
    a. at correct height

NOTE: 2" x 4" shorts cut to proper length may be used as vertical spacers

    b. with edge of waler to back of supports
3. Toe-nail waler to supports with 12d duplex-head nails

   a. smooth face to chalk line
   b. sides butted flush and aligned
   c. exactly opposite outside form panels when tie holes were drilled
   d. in vertical position

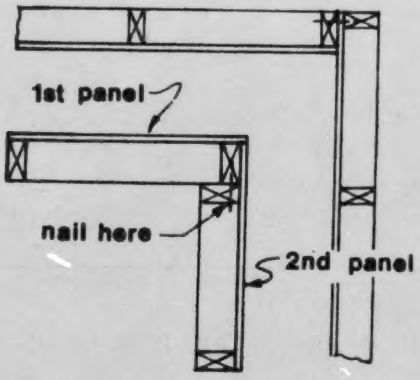
NOTE: Position ties as each panel is erected

5. Nail panel sections together similar as outside panels - step #4
6. Brace inside wall forms similar as in step #5
   a. two or three places
   b. temporarily

8. Construct Filler Panels

1. For inside corners one corner at-a-time
2. After all other wall forms are in place
3. Measure panels accurately
   a. from bottom end of inside wall form
   b. to inside corner of foundation wall marked on foundation footing
   c. each wall forming inside corner
4. Cut panels
   a. one to size (length measured)
   b. one to size less panel wall thickness
   c. cut square, straight, clean

A. Construct 1st Panel



Inside Corner Construction
WALL FORMS

1. Cut sole and top plate from 2" x 4" stock
   a. accurately, square
   b. length equal panel width minus panel thickness
2. Cut vertical supports - (2) each panel
   a. accurately; square
   b. length equal panel height minus 3"
3. Nail plates, vertical supports into a box frame
   a. position members on edge in a box frame
   b. supports butted into plates
   c. spike thru plates into supports while holding frame square
   d. with 16d common nails set flush
4. Nail frame to panel

- a. two or three places
- b. to hold waler in place
- c. until ties are set

NOTE: When using double walers or more than one tier of wales stagger joints (end butts) for strength

B. Drill Panels for Ties

1. At proper spacing
2. Position inside panels against outside panels
    - a. smooth sides flush against each other
    - b. in upright position
    - c. inside form panel butted together with equal space at each end between outside forms
3. Drill holes
    - a. through both form panels at once
    - b. size and spacing as per form calculations and manufacturer's instructions

NOTES: 1) There are numerous form ties manufactured and sold for this purpose. Follow manufacturer's instructions closely for assembly directions and hole size

2) Any re-bar required in foundation walls may have to be installed between erection of outside and inside wall forms. This fact must be considered at this time

7. Erect Inside Form Walls

1. Lay inside panels back
2. Sweep footing clean
3. Pop chalk line on top of footing
    - a. to mark location of inside wall forms
    - b. parallel to base of outside form panel
    - c. wall thickness away from outside form
4. Position inside form panels similar as outside form panels - step #4

  - a. flush at top, bottom, side away from corner
  - b. with 6d common nails set flush
  - c. spike thru panel face into frame

B. Construct 2nd Panel

1. Cut sole and top plate
   - a. accurately; square
   - b. length equal panel width minus 3½"
2. Nail plates, vertical supports into a box frame similar as 1st panel
3. Nail box frame to form panel similar as previous panel

NOTE: Flush at top, bottom, side away from corner

C. Assemble Panels

1. To form inside corner
2. Position panels in a vertical position
3. Fit panels together squarely so that panels form edge butt joint
4. Nail panels together with 16d duplex-head nails
   - a. thru vertical support - panel #2
   - b. into vertical support - panel #1

9. Install Corner Panels

NOTE: Sweep top of foundation footing clean between wall forms before closing in corners. Make exerted effort to keep footing clean inside forms from this point on

1. Position assembled corner panel
2. To inside corners one-at-a-time
   - a. panel faces to chalk lines on foundation footings
   - b. panels butted flush to existing panels
3. Nail to existing panels
   - a. with 16d duplex-head nails
   - b. spike thru vertical supports
   - c. while holding in place

10. Complete Wall Forms

1. Set inside wales as required
   - a. similar as outside form wales
   - b. opposite outside form wales
2. Check position, and affix all form ties

II. PRESENTATION (CON'T)

NOTE: Follow manufacturer's specifications and directions on installation of all form ties

3. Complete all braces similar as per previous braces

11. Check Form Construction

1. To be dimensionally correct
   a. overall dimensions; out-to-out
   b. wall thicknesses
   c. wall heights level
2. For proper alignment
   a. forms straight
   b. forms plumb
   c. corner square
   d. joints butted flush
3. For strength
   a. ties positioned properly
   b. braces rigid
   c. construction firm; sound
   d. joints solid

III. APPLICATION (PRACTICE BY LEARNER UNDER CLOSE SUPERVISION)

1. Students become familiar with job, tasks
   a. study general procedures
   b. study specific job; blueprints and plans
   c. discuss specific job, task sheets
   d. instructor make team job assignments

2. Field Trip! Students check job site against blueprints
   a. Elevations - set up level instrument and check elevations, level of foundation footing with surveyor's rod
   b. Dimensions - drop building corners to footing top and check building dimensions

3. Calculate cubic yards of concrete required for foundation walls. Calculate lateral loads of plastic concrete for linear foot of foundation wall. See lesson II-B- (I)

4. Select and compose Bill of Material for foundation wall forms. See lesson II-B- (I)

5. Pre-fab form panels for foundation wall

IV. VERIFICATION AND/OR EVALUATION (CHECK ON STUDENT'S ABILITY)

Performance Test!

Students erect and brace foundation wall forms in accordance with foundations and specifications within acceptable allowances following sound building practices and procedures

V. SUMMARY (TELL THE STEPS ON PROCEDURE AS TO WHAT, HOW, AND WHY. REVIEW CHECKING STANDARDS. THIS SUMMARY MAY BE GIVEN AT ANY PLACE IN THE LESSON THE TEACHER FEELS WILL BE PROFITABLE TO THE STUDENTS.)

Become familiar with specific job requirements; wall heights, thickness, lengths. Study blueprints! Calculate form requirements: weight of plastic concrete per lineal foot of wall; lateral pressure exerted; select material, design forms, compose Bill of Material.

Construct form panels. Height and width dictated by wall height, panel material size. When necessary cut panels to size with smooth, straight, square cuts. Nail frame (sole, top plate, vertical supports) flush to panel edges, thru panel face with 6d common nails. Nail frame members with 16d common nails. Set nail heads flush!

Erect outside forms. Drop building corners to footing top with plumb-bob. Pop chalkline on top of footing between corners marking building lines. Position panel faces to building lines. Start at one corner, butt panels flush against each other (last panel may overlap at corner). Nail panels together thru vertical supports each side of panel with 16d duplex-head nails.

Brace outside forms while holding in place. Use 2" x 4" knee braces where sized and positioned horizontally and toe-nailed to vertical supports of form panels. Ties installed as per manufacturer's instructions. Position inside form panels in position against outside forms. Drill holes, spaced and sized for ties thru both forms; position ties in outside forms.

Erect inside forms. NOTE: If reinforcement steel is required in the foundation wall it should be installed at this time. See Lesson II-1- . Lay forms back; sweep top of foundation footing clean; pop chalkline to mark inside of foundation wall. Position inside form panel to line one-at-a-time assembling ties as panel is positioned. Butt panels flush in line in vertical position and nail together as outside panels.

Brace inside forms similar as outside forms.

Construct filler panels for inside corners and assemble into inside corner form. Position and nail in place.

Complete inside forms. Install wales as required opposite and similar to outside.

Check form construction (all), dimensionally; alignment; construction; strength.

SUGGESTED READING FOR STUDENTS:

The World of Construction, pp. 220-225

The Next Lesson Is: II-E-1(S), "Set And Tie Reinforcing Steel - Monolithic Slab And Beam Foundation"

II-B-3(J)

JOB SHEET
IN
SETTING CONCRETE FORMS

NAME OF JOB: Construct/Erect Foundation Wall Forms

MATERIAL: Plywood/plyform panels as required; 2" x 4" framing lumber as required; 6d, 16d common nails; 12d, 16d duplex-head nails

TOOLS AND EQUIPMENT: 6' folding rule, framing square, straight edge, portable circular saw, hand saw (cross cut), claw hammer, sledge hammer, carpenter's level, plumb bob, chalkline, string line (nylon), portable power drill, drill bits

GENERAL INSTRUCTIONS: Foundation wall forms are generally placed on concrete footings. Exercise care that the wall forms are of correct height to bring foundation walls to specified elevation by double checking physical "on site" dimensions before commencing form panel construction.

Most form panels can be pre-constructed and moved to the site for erection. The exception being, "inside corner filler panels". These must be constructed on site to fit after all other panels are in place. Follow the step-by-step procedures in the tasks list below for proper erection of foundation wall forms.

PROCEDURE AND/OR TASK: II-B-3(TS) Construct Form Panels

CHECK POINTS: Check with supervisor on form design before constructing form panels

II-B-3a(TS) Erect Outside Wall Forms

CHECK POINTS: Check form alignment, level, plumb before securing form braces to brace stakes

II-B-3b(TS) Erect Inside Wall Forms And Install Form Ties

TASK SHEET

TASK: Construct Form Panels

JOB: Construct/Erect Foundation Wall Forms

TRADE: Building Trades

TOOLS AND MATERIALS: Skill saw, framing square, plywood panels as required, hand saw, straight edge, framing lumber as required, 6' folding rule, claw hammer, 6d and 16d common nails

TASK BREAKDOWN:

STEPS	KEY POINTS
1. Study Plans, Details	1. Height of foundation walls 2. Length of foundation walls outside - inside
CHECK POINTS:	Verify site dimensions against drawings; especially T.O.C. footing to T.O.C. wall
2. Calculate Form Requirements	Note: Review Information Sheet II-B-1a(IS) 1. Calculate lateral pressures to be exerted on forms 2. Determine form panel design: a. Direction of face grain of panels b. Size, thickness of panels c. Number of panels required d. Number, size, spacing of vertical e. Number, size, spacing of walers, if any f. Number spreaders, their location and spacing
CHECK POINTS:	Check with supervisor on design and strength of forms
3. Cut Panel Boards	1. To size 2. From standard sheets of plywood/plyform 3. Cut straight; square
4. Cut Panel Support Members	1. Accurate; ends square 2. Sole, top plate to panel length 3. Vertical supports to panel height less 3" 4. From select 2" x 4"s
5. Assemble Support Frame	1. Position panel on flat nailing surface, face down

STEPS	KEY POINTS
	2. Position sole, top plate on sides, flush with bottom, top of panel
	3. Position vertical supports on sides, flush at each end of panel, equally spaced according to design dimension in middle, perpendicular with plates
	4. Secure with 16d common nails; (2) each joint. Spike through plates into supports at top and bottom while holding in place
6. Assemble Form Panel	1. Position assembled support frame flat on nailing surface
	2. Position form panel on top of frame - all edges flush with edges of frame
	3. Secure with 6d common nails spaced on 10" intervals
	4. Spike through form panel into center of support frame members

TASK SHEET II-B-3a(TS)

TASK: Erect Outside Wall Forms

JOB: Construct/Erect Foundation Wall Forms

TRADE: Building Trades

TOOLS AND MATERIALS: Form panels (as constructed), claw hammer, plumb bob, walers, if necessary, sledge hammer, chalkline, 2" x 4" brace stakes, carpenter's level, string line, 2" x 4" horizontal braces, hand saw

TASK BREAKDOWN:

STEPS	KEY POINTS
1. Locate Foundation Outside Wall Lines	1. On batter board ledgers as per plans and details a. Measure out from building lines b. Mark and notch ledgers to receive string lines c. Reset string lines on batter boards 2. On foundation footings swept clean a. With plumb bob suspended from intersection of string lines, mark corners on T.O.C. footing b. With chalkline stretched taut between corner marks, "snap" chalkline to mark outside wall lines
2. Set Outside Form Panels	1. One-at-a-time, one wall-at-a-time 2. Start at one corner a. With panel (smooth) side in b. With panel base to chalkline c. With panel top to string line 3. Place panels in a straight line butted together and flush Note: On outside corners, one panel may overlap. On inside corner, filler panels may be construced after all other panels are in place
3. Spike Panels Together	1. With 16d duplex-head nails 2. Through vertical supports each end of panels 3. Spaced 10"-12" alternately from opposite sides
4. Spike Corners Together	1. Through back of panel overlapping 2. Into vertical support of panel forming corner

STEPS	KEY POINTS
	3. Using 12d duplex-head nails
	4. While holding corner panels in position
5. Position Horizontal Braces	1. Extending out 90^{0} from back of form
	2. On edge, with one end on top of sole plate and against a vertical support
	3. Space on approximate 4'-0 intervals or as per design requirements — start at a corner
6. Secure Brace To Form	1. With (2) 12d duplex-head nails
	2. Spike through brace into vertical support
	3. While holding brace in position
7. Position Diagonal Braces	1. One-at-a-time
	2. On top of horizontal braces
	3. Set at proper angle
	4. With side of brace against form vertical support at upper end
8. Secure Brace To Form	1. With (2) 12 duplex-head nails
	2. Spike through brace into form
	3. While holding brace in position
9. Set Form Stakes	1. Edge flush against sides of braces on outboard end
	2. Drive stake vertically into ground firm
	3. Allow sufficient amount of stake above ground to secure braces
10. Secure Braces To Stakes	1. Check form alignment, plumb, level
	2. Adjust forms as necessary
	3. With (2) 12d duplex-head nails each brace
	4. Spike through brace into stake
	5. While backing stake
11. Install Wales	1. To outside of forms as required per design calculations a. Select material size, quality, lengths
	Note: When using double walers or more than one tier of walers, stagger joints for strength
	b. Lay out wales

STEPS	KEY POINTS
	2. Position horizontally outside and against vertical supports of form panels
	3. Toe-nail waler to vertical supports sufficiently to hold waler in place using 12d duplex-head nails

TASK SHEET

TASK: Erect Inside Wall Forms And Install Form Ties

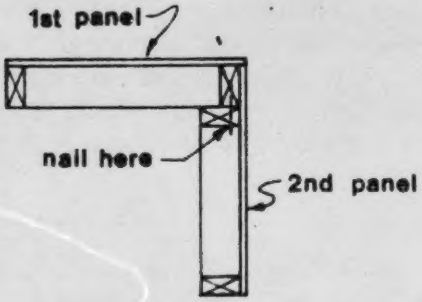
JOB: Construct/Erect Foundation Wall Forms

TRADE: Building Trades

TOOLS AND MATERIALS: Form panels (as constructed), 6' folding rule, string line (nylon), walers, if necessary, hand saw, chalkline, 2" x 4" brace stake, framing square, portable power drill, 2" x 4" horizontal braces, straight edge, drill bits, plywood/plyform panels, claw hammer, portable power saw, 2" x 4" panel frame material, sledge hammer, 6d and 16d common nails, 12d and 16d duplex-head nails

TASK BREAKDOWN:

STEPS	KEY POINTS
1. Locate Foundation Inside Wall Lines	1. On batter board ledgers 2. On foundation footings swept clean 3. Similar as outside wall lines of previous task
2. Mark And Drill Tie Holes (If Required)	1. Position inside form panels inside a. In upright position against outside panels b. With panel faces touching c. Butted end to end; one wall-at-a-time d. With equal spacing at each end to outside forms 2. Mark and drill holes through both panels at one time a. Location, spacing, size as per design calculations and manufacturer's instructions b. Using portable power drill
3. Reposition Inside Form Panels	1. On chalkline a. With smooth side of panel to inside of form b. With panel top touching string line c. With panel base touching chalkline 2. Keep panels butted end to end flush and straight 3. Maintain equal space at each end to outside forms
4. Spike Panels Together	Similar as outside panels, previous task II-B-2a(TS)

STEPS		KEY POINTS
5. Brace Inside Panels		Similar as outside brace, previous task II-B-2a(TS)
6. Construct Filler Panels  Inside Corner Construction	1. 2. 3. 4. 5. 6.	For inside corners one-at-a-time After all other forms are in place Measure panel size accurately a. From end of last standard panel b. To inside corner marked on foundation footing Cut one panel to size and one panel to size minus one panel thickness(see sketch to left) Construct support fromes similar to previous tasks — note special treatment in corner (see sketch to left) Assemble corner panels to frame supports similar as previous tasks — assemble panels into corner panel as per sketch at left
7. Spike Panels Together	1. 2.	Similar as previous tasks While holding in position
8. Brace Inside Wall Forms		Similar as outside wall forms, task II-B-3a(TS)
9. Install Inside Wales		Similar as outside wales, task II-B-3a(TS)
10. Install Form Ties		As per manufacturer's instructions

INSTRUCTOR'S PLAN
INFORMATIONAL LESSON

SUBJECT: Concrete Reinforcement

AIM: The student will be able to identify, place, and tie steel reinforcement according to blueprints and specifications in the preparation of concrete building foundations.

TEACHING AIDS: Information sheet II-E-1(IS), Reinforcing; Chalkboard

MATERIALS: Samples: 1' long pcs., various dia. rebar
Small sections, welded wire fabric

REFERENCES: The World of Construction, pp. 220-225
Concrete Technology, pp. 98-102
Methods and Materials of Commercial Construction, pp. 85-87

PREREQUISITE EXPERIENCE OF THE LEARNER: The student must have successfully completed Major Block I, "Orientation", and Lesson II-A-2(I), "Blueprint Reading". The student must further exhibit an enthusiasm for learning the building trades.

I. PREPARATION (OF THE LEARNER - MOTIVATION)

Concrete is by far the most widely used of all modern construction materials. The fact that it is worked, cast, and formed while in a plastic state (semi-fluid), makes it extremely versatile for forming precast concrete products such as concrete pipe, conduct, brick, septic tanks, floor and roof tiles, decorative pieces, columns, beams, and walls. Concrete will not rust, corrode, decay, or deteriorate and is extremely strong in compression.

Concrete has one drawback. It has very little tensile strength, that is, little resistance to stresses or forces that want to bend or pull it apart. To remedy this, concrete must be reinforced. Many materials have been tried, but steel is universally accepted and used for this purpose. One important advantage of steel is that its contraction and expansion characteristics, due to temperature changes, are nearly the same as those of concrete. Reinforcing steel must be set in the forms before the concrete is placed.

II. PRESENTATION (OF THE INFORMATION)

INSTRUCTIONAL TOPICS TEACHING POINTS	THINGS FOR STUDENTS TO DO THINGS FOR INSTRUCTOR TO DO OR SAY
A. Purpose of Reinforcement	1. Tensile strength 2. Increases compressive strength 3. Resist internal stresses of concrete a. Shrinkage during curing

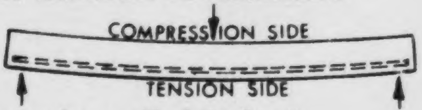
b. Expansion/contraction caused by temperature change

4. Distribute loads throughout concrete

B. How Reinforcement Works

1. Concrete very strong under compression
2. Concrete very weak in tension
3. Concrete subjected to various tensile forces
   - a. Straight tensile pull
   - b. Bending forces
4. Reinforcement placed in concrete in areas of tension

Example: Illustrate on chalkboard



C. Types of Reinforcement

Passout: II-E-1(IS)

1. Reinforcing bar called "rebar"
   - a. Round steel bars
   - b. Have upset pattern of ridges for greater holding power
2. Welded wire fabric
   - a. Made of steel wires at right angles with each other
   - b. Resistance welded at intersections
   - c. Forms a wire "mesh"
   - d. Lengthwise wire called "longitudinal"
   - e. Crosswise wire called "transverse"

D. Sizes of Reinforcement

Note: Display samples

1. Rebar

1. Sized by diameter
2. Designated by a number equaling the diameter in eighths-of-an-inch

   Examples:

   *2 = ¼" DIA., *3 = ⅜" DIA., *4 = ½" DIA., *5 = ⅝" DIA.
3. Diameters - 1/4" to 1" dia. and above; in 1/8" increments
4. Lengths - 20', 40' standard; 60' available from mill

2. Wire Fabric

1. Made by wire fabric welding machine
   - a. Longitudinal wires fed through machine
   - b. Transverse wire fed across machine
   - c. Wires criss-cross, forming a "mesh"
   - d. Wires are resistance welded at intersections to form a fabric
2. Fabric produced in 4', 5', 6' rolls; 100', 150' long
3. Fabric is sized by a combination of:

   - a. Mesh size (size opening between wires)
   - b. Wire gage size
4. Designated by combination of number denoting same
   Example: See information sheet II-E-1(IS)
5. Standard wire spacing
   - a. Longitudinal wires - 2" - 16" in 1/2" increments
   - b. Transverse wires - 1" - 18" in 1" intrevals
6. Popular wire sizes - 6, 8, 10, 12 gage
7. Available in practically any mesh but may have to be special ordered

E. Preparing Reinforcement

1. Architects' drawings show:
   - a. Size of reinforcement
   - b. Location, spacing, and direction of reinforcement
   - c. Special detail - hooks, bends
2. Contractor submits drawings and/or Bill of Material to vendor where he plans to buy
3. Vendor makes shop drawings if necessary
   - a. Cuts material to length
   - b. Makes necessary bends
   - c. Bundles like pieces
   - d. Labels bundles for identification
   - e. Delivers steel to job site
4. Reinforcement must be free of oil, paint, excessive rust or dirt before placement

F. Placing Reinforcement

1. Done by workers called "rodsetters"
2. Rodsetters work in pairs; teams
3. Sequence of placement must be systematic
   - a. Lowest bars placed first
   - b. Cross bars placed second
4. Place rods according to shop drawing and foundation drawing
   - a. Identify pieces by shop labels
   - b. Place pieces according to foundation drawing dimensions, spacing, and direction
5. Place wire mesh in long direction of building foundation
   - a. Lay out roll to proper lengths outside of forms

   b. Place curl down and walk on mesh to flatten - position in forms

Notes: Exercise care not to tear moisture barrier
Be safety conscious! Wear safety apparel; heavy work gloves

G. Lap, Splices

1. Wire fabric - overlap one full mesh size plus 2"
   Example: 6 x 6 mesh overlap 8"
2. Rebar splice - overlap 24 rod diameters or 12" minimum, whichever is greater
3. Secure laps; splices with wire ties

H. Wire Ties

1. Allow better control of bar spacing
2. Make easier to place bars in form
3. Locks bars into solid mat
4. Holds bars in vertical reinforcing
5. Made in various gage soft steel
   a. 16 gage most common
   b. Easy to bend, twist
6. Often pre-cut to designated length
7. Should be worked with good pair side cutting pliers

I. Tying Procedure

1. Position rebar accurately
2. At intersection of rebars - lift lower bar off ground to clear
3. Run tie wire under both bars diagonally at intersection
4. Bend ends of tie wire up forming a "U"
5. Twist ends of tie wire with side cutting pliers until tie is tight
6. Cut off excessive wire
7. Bend/beat twist parallel to ground

J. Reinforcement Accessories

1. Are used to hold reinforcement in position within forms
2. Allow plastic concrete to work around reinforcement when placed
3. Position and space as required
   a. To hold rebar off ground
   b. To provide proper position of rebar in the concrete
4. Types
   a. Show samples

b. Illustrate proper use

III. APPLICATION (DRILL, ILLUSTRATIONS, ANALOGIES, ORAL QUESTIONS OR ASSIGNMENTS, MAKING INVESTIGATIONS OR EXPERIMENTS, NOTE TAKING, MAKING SKETCHES, PARTICIPATING IN DISCUSSION.)

Passout: Assignment sheet II-E-1(A), "Concrete Reinforcement"
Students complete assignment as per instructions

IV. VERIFICATION AND/OR EVALUATION (FINAL CHECK ON STUDENT'S COMPREHENSION OF MATERIALS PRESENTED.)

Questions: Simple Recall

1. The most widely used of all modern construction material is _____.	concrete
2. Concrete is extremely strong in _____.	compression
3. Concrete must be worked/formed while in a _____ state.	plastic
4. The purpose of reinforcement of concrete is ___.	tensile strength
5. Steel bars placed in concrete are commonly called _____.	rebar
6. The pattern of ridges on steel bars placed in concrete produce greater _____.	holding power
7. A #6 rebar is _____ inches in diameter.	3/4
8. Rebar is available in standard lengths of 20' and ___.	40'
9. Foundation fabric wire is sized by wire _____.	gage
10. Wires running the lengthwise in foundation fabric are referred to as _____ wires.	longitudinal
11. The fabric size designation 6 x 8 / 10-10 denotes spacing of transverse wires to be _____.	8"
12. Wire fabric should be overlapped one mesh plus ___.	2"
13. Reinforcement is set by workers called _____.	rodsetters
14. #3 rebar should be overlapped _____ inches.	12
15. Wire _____ allow better control of bar spacing and locks bars into a solid mat.	ties

V. SUMMARY (GIVE A BRIEF ACCOUNT OF EACH TOPIC REEMPHASIZING THE IMPORTANT POINTS. THIS SUMMARY MAY BE GIVEN AT ANY PLACE IN THE LESSON THE TEACHER FEELS WILL BE PROFITABLE TO THE STUDENT.)

Concrete is the most widely used of all modern construction materials. Since it is worked while in a plastic (semi-fluid) state, it may be cast into a variety of concrete products such as pipe, conduit, septic tanks, floor and roof tiles, decorative columns, beams, and walls. Concrete will not rust, corrode, decay, or deteriorate and is extremely strong in compression. Concrete has one drawback. It has very little tensile strength; that is, little resistance to forces that tend to bend it or pull it apart.

To remedy this, concrete must be reinforced! Many materials have been tried, but steel is universally accepted and used for this purpose. One important advantage of steel is that its contraction and expansion characteristics, due to temperature changes, are nearly the same as concrete.

Concrete reinforcement is manufactured in two general types: bar and welded wire fabric. Bars are sized by their diameter from ¼" to 1 ¼" and larger in 1/8" increments and are available in 20' and 40' lengths. The surface of reinforcing bars have an upset pattern of ridges to provide greater holding power in the concrete. Welded wire fabric is made of heavy gage steel wire resistance welded into a solid mesh sold in rolls 4', 5', 6' wide and 100', 150' long. Practically any gage wire and mesh spacing is available, although some sizes may have to be special ordered.

When plans and specifications call for reinforcement the builder submits drawings or a bill of materials to the vendor where he plans to buy. The vendor makes shop drawings and upon the builder's approval, cuts rebar to length, makes all necessary bends, labels and bundles all like pieces, and delivers the reinforcement to the job site. Workers, called rodsetters, unbundle, set, and tie the steel in place. Rodsetters must be able to read blueprints and shop drawings in order to coordinate the placing of steel; the sequence of placement, the direction of the bars, and their spacing. They must also know the proper procedure for overlapping rod and fabric and tying reinforcement into a solid mat. "Rodsetter" on large construction projects is a job speciality in which rodsetters generally work in pairs or teams. It is indeed a responsible job that if not performed properly may cause foundation and structure failure.

SUGGESTED READING FOR STUDENTS:
Modern Carpentry, pp. 101-110
Fundamentals of Carpentry, pp. 100-104

THE NEXT LESSON IS: II-G-1(I), "Cement/Concrete"

INFORMATION SHEET
ON
CONCRETE REINFORCEMENT

SUBJECT: Reinforcing Steel

INTRODUCTORY INFORMATION:

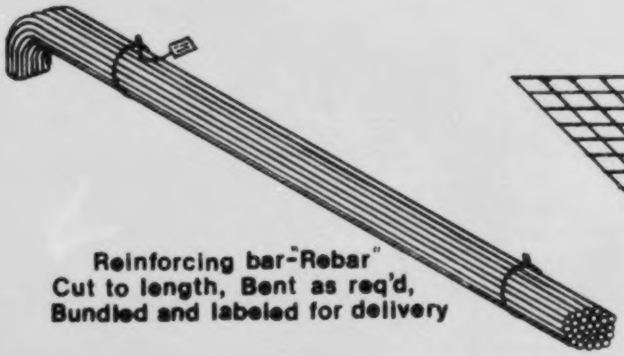
Concrete is the most widely used building material in the world. The fact that concrete must be worked, cast, formed while in its plastic (semi-fluid) state makes it extremely versatile for forming precast building products in addition to conventional uses such as foundations, beams, columns, etc. Other qualities which lend to its popularity as a building material are: when hardened, it becomes a strong, durable, watertight material resistant to abrasion and deterioration - strength referring to strength of compression.

Concrete has one major drawback. It has very little tensile strength. That is, little strength to pulling or bending forces. To remedy this, concrete exposed to such forces must be reinforced.

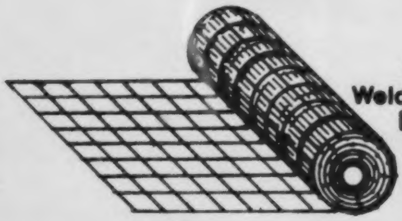
GENERAL INFORMATION:

Many materials have been tried as concrete reinforcement. However, steel is universally accepted and used for the purpose. One important advantage steel has over other materials is that its expansion and contraction characteristics, due to temperature changes, are nearly the same as those of concrete.

Steel reinforcement is manufactured in two basic forms: reinforcing bars and welded wire fabrics.



**Reinforcing bar-"Rebar"
Cut to length, Bent as req'd,
Bundled and labeled for delivery**

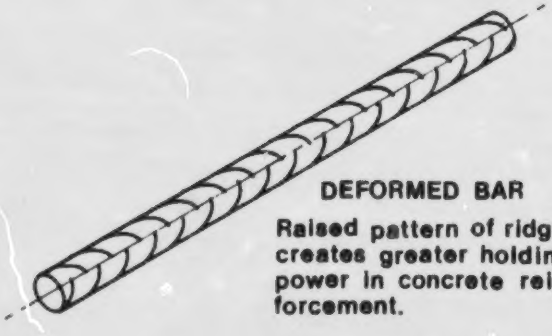


**6×6/10-10
Welded Wire Fabric
(5'×150' Roll)**

Reinforcing bar, called rebar, is sized by its diameter and is designated by a number which usually indicates the diameter size in eighths-of-an-inch. Example: #5 rebar is 5/8" in diameter. Sizes range from #2, ¼" dia. to #18, 2¼" dia. (see chart) and are normally available in lengths of 20' and 40'.

Common Re-bar Sizes

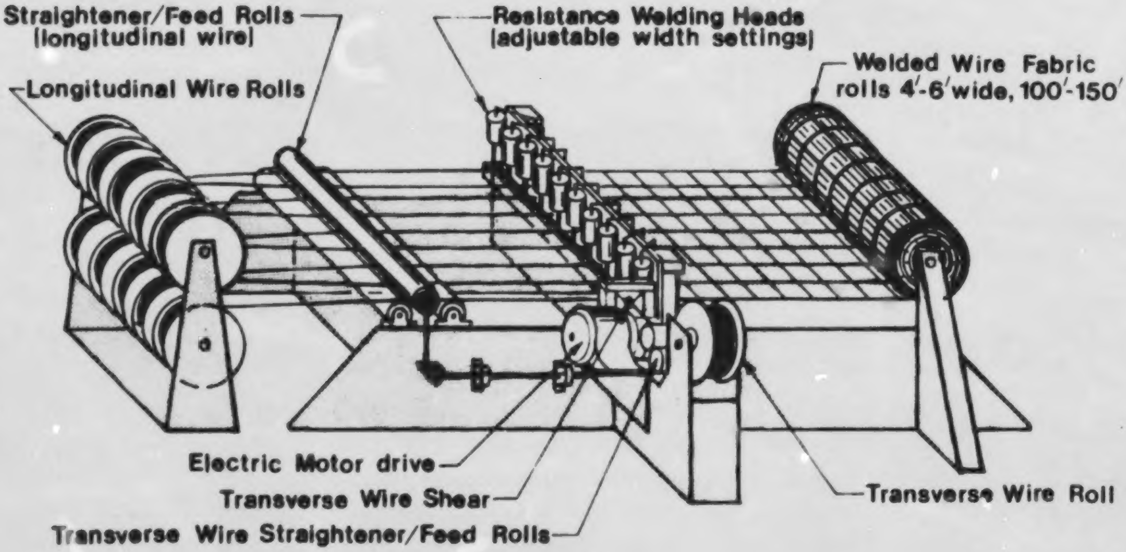
BAR NO.	SIZE DIA.	AREA SQ. IN.	WEIGHT LBS./FT.
2	¼	0.05	0.167
3	⅜	0.11	0.376
4	/2	0.20	0.668
5	⅝	0 31	1.043
6	¾	0.44	1.502
7	⅞	0.60	2.044
8	1"	0.79	2.670
9	1.13	1.00	3.400
10	1.27	1.27	4.303
11	1.41	1.56	5.313
14	1.693	2.41	8.18
18	2.257	3.98	13.52



DEFORMED BAR

Raised pattern of ridges creates greater holding power in concrete reinforcement.

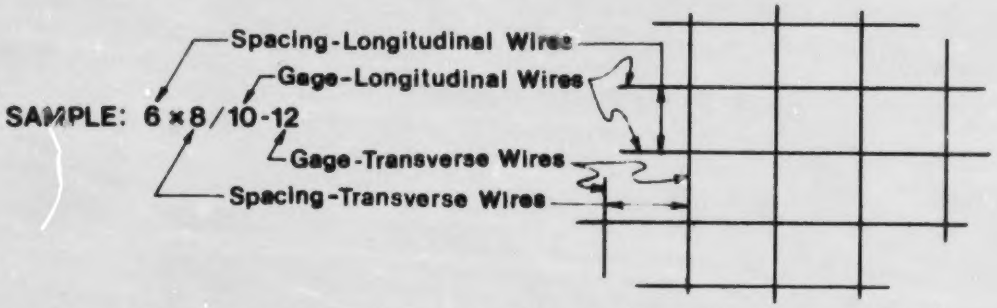
All reinforcing bars, except the $\frac{1}{4}$" size, are deformed bars; that is, they have a raised or upset pattern on the bar. This provides a greater surface area for bonding and holding to concrete. When a builder is required to use rebar in his concrete, he usually submits the foundation drawings and specifications to the vendor where he plans to purchase the material. The vendor composes a bill of material, makes shop drawings if necessary, cuts material to length, makes all necessary bends, labels and bundles all like pieces, and delivers rebar to job site ready to position.


Straightener/Feed Rolls (longitudinal wire)
Resistance Welding Heads (adjustable width settings)
Welded Wire Fabric rolls 4'-6' wide, 100'-150'
Longitudinal Wire Rolls
Electric Motor drive
Transverse Wire Shear
Transverse Wire Straightener/Feed Rolls
Transverse Wire Roll

WIRE FABRIC WELDING MACHINE

Welded wire fabric is made by a special welding machine. Long rolls of steel wire, called longitudinal wires, are fed through the machine at a given rate of speed. The wire size and spacing are predetermined and set to manufacture a particular fabric. A transverse steel wire is fed across the longitudinal wires at timed intervals, cut to length, and resistance welded at the wire intersections to produce a wire fabric of given wire size and mesh. The fabric in 4', 5', or 6' widths is then rolled into 100' or 150' lengths for purchase.

Wire fabric is designated by a combination of its mesh size - size opening or spacing between wires, and wire size - the gage number of the size wire used.

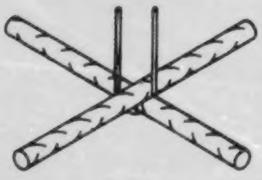


Welded wire fabric is available in practically any size but may have to be special ordered. Standard wire spacings are: longitudinal wire - 2" thru 16" in $\frac{1}{2}$" increments; transverse wire - 1" thru 18" in 1" intervals. Popular wire sizes are 6, 8, and 10 gage.

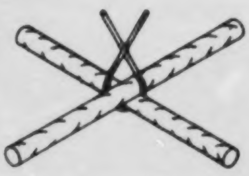
Reinforcement must be set and tied before the concrete is placed. This work, on large construction, is performed by workers called "rodsetters" and is considered a job specialty. Rodsetters must be able to read blueprints and shop drawings, determine the sequence of placement, and systematically place and tie the reinforcement according to directions and spacings on the blueprints.

Tying reinforcement serves several purposes. It makes it easier to place the bars in the forms; it allows better control of bar spacing; it holds horizontal bars to vertical bars; and it locks rebars into a solid mat. Ties are made with a soft steel wire, approximately 16 gage, cut to desired length, placed diagonally around the intersection of reinforcing steel, and twisted at the ends to make a tight, snug tie (see illustration). After the tie is made the excess wire should be clipped and the twist bent over to prevent possible injury.

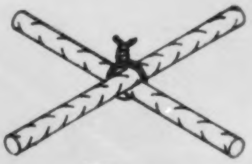
Loop tie wire diagonally around intersections of reinforcing steel



Twist wire with side-cutting pliers to tighten tie

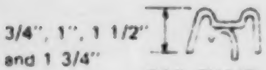


Cut off excess wire and bend twist down to prevent injury

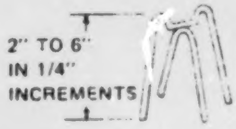


On occasion rebar must be spliced in the field. This is done by simply overlapping the ends and tying with two wire ties. The overlap should be a minimum of 24 rod diameters or 12", whichever is greater. Wire fabric should be overlapped one mesh size plus 2". In working wire fabric, care should be exercised not to let the unrolled fabric recoil causing possible injury to co-workers. The fabric should be unrolled and cut to lengths to equal that of the building. The fabric should be turned "curl down" and walked on or otherwise flattened before placing in the forms. A team of workers should place the unrolled fabric in the forms according to blueprints and specifications, practicing the proper overlap, and exercising care not to tear or puncture any moisture barrier placed prior to steel reinforcement.

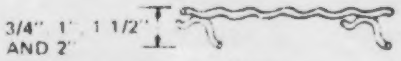
After the reinforcement is positioned and tied into a mat, it must be raised and held a given distance off the foundation base to insure the reinforcing steel will be properly imbedded in concrete when placed. There are several devices manufactured for this purpose. Placement of these accessories between the foundation base and the reinforcement is at random, but sufficient numbers should be used to properly hold the mat off the base. Some of the more common devices are shown below.



BAR CHAIR



HIGH CHAIR



SLAB BOLSTER

INSTRUCTOR'S LESSON
MANIPULATIVE LESSON

II-E-1(S)

TASK:	Set And Tie Reinforcing Steel — Monolithic Slab And Beam Foundation
AIM:	The students will be able to place and tie reinforcing steel for simple slab and beam foundations according to blueprints and specifications following acceptable building practices and procedures.
TOOLS AND EQUIPMENT:	18" bolt cutters, 8" electrician's side cutting pliers, 10'-12' steel measuring tape
MATERIALS:	Reinforcing steel as required by blueprints and specifications tie wire (16 gage soft steel wire) as required
TEACHING AIDS:	Job Sheet II-E-1(J)
PREREQUISITE EXPERIENCE OF THE LEARNER:	The student must have successfully completed previous lessons II-D-1(I), Personal And General Safety, II-A-2(I), Blueprint Reading, and II-E-2(I), Concrete Reinforcement
CHECKING STANDARDS:	1. Material sizes agree with blueprints; specifications 2. Steel correctly placed, tied to form rigid matt 3. Steel adequately held in position

I. PREPARATION (OF THE LEARNER - MOTIVATION)

Reinforcement is the term used for the steel bars and/or wire fabric that is placed in concrete to increase its tensile strength. Practically all concrete used in building and construction contains reinforcement. On large projects, reinforcement steel is set and tied in place by job speciality crafts people called "rodsetters." However, on smaller projects, this job is performed by general construction workers, and sometimes, even carpenters are called on to set and tie reinforcing steel.

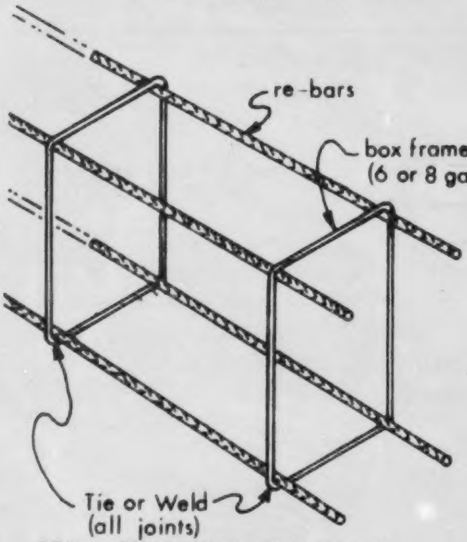
A good carpenter should be prepared to perform this job with the same confidence he has in building concrete forms.

II. PRESENTATION (OF THE SKILLS)

STEPS	KEY POINTS (THINGS TO REMEMBER TO DO OR SAY)
1. Study Drawings; Specifications	1. Type(s), sizes of reinforcement employed 2. Vendor's numbering/coding system is used 3. Special configurations a. Hooks; bends b. Sub-assemblies, if any

4. Location
   a. Position and direction of reinforcement
   b. Spacing (re-bar)
5. Sequence of placement

2. Prefabricate Beam Reinforcing Steel



BEAM REINFORCEMENT FRAME

1. Into a rigid framework
2. One beam-at-a-time
3. Form box frame spacers
   a. From #8 gage steel wire, or as specified
   b. To hold re-bar properly spaced
4. Position bottom re-bars on flat surface
   a. Size and length as per foundation drawings
   b. Spaced parallel as per sections and details
5. Slide box frames over re-bars and tie in upright position on 6' - 8' intervals
   a. Position re-bar in lower corner of frame
   b. Place tie wires diagonally opposite to hold frame upright
   c. Twist wires for a tight tie (See sketch to the left)
6. Position remaining re-bar
   a. One-at-a-time
   b. Inside of box frames
   c. Spaced according to dimensions
7. Tie as per bottom re-bars

Note: Beam reinforcement may come as a prefabricated weldment from the vendor. In such cases omit step #2

3. Position Beam Reinforcement

1. In beam excavations one-at-a-time
2. Work as a member of a team
3. Practice safety:
   a. Proper lifting, carrying techniques
   b. Protective clothing, gloves
   c. Caution in handling — jagged ends, burrs
   d. Exercise care not to damage (break) excavation walls or moisture barriers
4. Aligned with forms where possible
   a. Use folding rule to set alignment
   b. Visually center when not possible
5. On appropriate chair, bolster, or other accessory to maintain proper space under reinforcement

4. Tie Beam Reinforcement

1. All corners, "T" intersections
2. To form rigid "beam" steel reinforcing frame
3. Use approximate 16 gage soft steel wire ties

		4. Twist wires snug to form tight ties
CHECK POINTS:		Check all beam reinforcing steel to be: a. Appropriately spaced above sub-base b. Properly aligned c. Sufficiently rigid d. Tightly tied
5.	Position Slab Re-bars	1. Longitudinal (long) bars first 2. Work in teams 3. Place re-bar inside forms a. Direction and spacing according to foundation's plans b. Aligned parallel with tape measure each end c. Visually straight 4. Transverse (cross) bars second a. On top and 90° to lower re-bar b. Spaced and aligned similarly to lower bars
6.	Tie Re-bar	1. Into a rigid matt 2. While holding rebar in position a. Run #16 gage soft steel wire tie, approximately 6" lg., under re-bar 1. At intersections of bars 2. Diagonally, while lifting off sub-grade Note: Do not tear moisture barrier b. Bend ends of wire up forming a "U" c. Twist ends of wire with electrician's side cutting pliers until tie is tight d. Cut off excessive wire e. Bend/beat twist over to prevent injuries from sharp ends of wire
7.	Adjust Matt (Re-bar) Height	1. To allow proper space between re-bar and sub-grade 2. Use appropriate bolsters, chairs, or other accessories as required for height 3. Place under matt strategically at regular intervals to maintain uniform height
8.	Tie Matt To Beam Reinforcement	1. At regular intervals 2. Make ties similar as per step #5 3. To form a rigid framework of steel reinforcement
9.	Place Wire Fabric	1. As per foundation plans and details

2. In long direction of building foundation
3. Working in teams
    a. Roll out lengths outside of forms
    b. Cut to length while holding rolled out fabric securely

Note: Uncoiled wire fabric has tremendous recoil power. Allowed to recoil freely, it may cause serious bodily injury

    c. Turn fabric over to place curl down
    d. Walk on fabric to flatten curl
4. Position fabric in forms
    a. Parallel with length of forms
    b. Starting at one side
    c. Overlap each preceding width one mesh plus 2"

Tie Wire Fabric

1. With wire ties spaced 3' - 4' apart
2. Similar as per re-bar
3. Along entire lap joint
4. Each/all lap joints

CHECK POINTS:

Check all reinforcement to be properly set, tied, and secure

III. APPLICATION (PRACTICE BY LEARNER UNDER CLOSE SUPERVISION)

Students study job and task sheets
Students become familiar with:
    a. General job procedures
    b. Specific task details
Students practice tying re-bar
Students construct reinforcing steel framework for a foundation beam according to instructor's specifications
Students exercise all safety practices and procedures
Class studies specified jobs, blueprints, and details
Instructor makes team assignments

IV. VERIFICATION AND/OR EVALUATION (CHECK ON STUDENT'S ABILITY)

Performance Test!

Students place and tie reinforcing steel for a foundation to a given set of plans and details

V. SUMMARY (TELL THE STEPS ON PROCEDURE AS TO WHAT, HOW, AND WHY. REVIEW CHECKING STANDARDS. THIS SUMMARY MAY BE GIVEN AT ANY PLACE IN THE LESSON THE TEACHER FEELS WILL BE PROFITABLE TO THE STUDENTS.)

*Become familiar with foundation plans, sections, details, vendor's drawings, and coding system before commencing job.

*Fabricate foundation beams reinforcing steel into a rigid framework if necessary before placing in position — fabricate according to plans and details.

*Exercise all safety practices and procedures when working with reinforcing steel — lifting, carrying techniques; appropriate safety clothing, apparel; safety consciousness.

*Position reinforcement in forms systematically — lower bars first, cross bars on top, parallel and equally spaced as per blueprints. Wire mesh in long direction of building foundation — overlapped one mesh +2" at seams.

*Tie reinforcement into a solid matt — rigid framework using soft steel wire ties.

*Adjust height of reinforcement to allow proper space between sub-base and reinforcement for concrete. Use chair, bolsters, or other accessories as required.

*Check all reinforcement to be properly set, tied, and secure.

SUGGESTED READING FOR STUDENTS:

Modern Carpentry, pp. 90-102
Concrete Technology, Units 12, 13, 14

THE NEXT LESSON IS: II-G-1(S) "Place And Finish Concrete - Monolithic Slab And Beam Foundation"

II-E-1(J)

JOB SHEET
IN
CONCRETE REINFORCEMENT

NAME OF JOB: Set And Tie Reinforcing Steel — Monolithic Slab And Beam Foundation

MATERIALS: Reinforcing steel bar — as required by blueprints and specifications weld wire fabric — as required by blueprints and specifications, #16 gage steel tie wires - as required; chairs, bolsters, as required

TOOLS AND EQUIPMENT: 18" bolt cutters, 8" electrician's side cutting pliers, hacksaw

GENERAL INSTRUCTIONS: There are four important aspects to setting steel for concrete reinforcement:

1. Placing of steel — should be in logical sequence; in right direction, properly spaced, correctly lapped for joints
2. Tying of steel — should be systematic, sufficient to form a rigid matt or framework of steel that will resist movement during placement of concrete
3. Maintaining proper space for concrete - between reinforcement and forms; between reinforcement and sub-grade
4. Perform above safely, efficiently

PROCEDURE AND/OR TASK:

1. Study blueprints, specifications, vendor's drawings and coding system to become familiar with job and determine a sequence for placing steel
2. Prefabricate beam reinforcing steel into rigid frames one beam-at-a-time using box frame spacers at regular intervals to maintain proper spacing of re-bars
3. Place beam reinforcement (rigid frame) in beam excavations, align and adjust heights of frames and tie all corners — "T" intersections a rigid beam framework — work in teams

CHECK POINTS: All beam reinforcing steel properly aligned; appropriate concrete space surrounding, ties tight; frame rigid

4. Place re-bar in proper sequence — direction and spacing according to foundation plans and details
5. Tie re-bar into rigid matt with #16 gage wire ties at all intersections — tie matt to beam steel similarly
6. Adjust matt height to allow proper space between matt and sub-grade for concrete — use appropriate chairs, bolsters, other accessories

7. Place wire fabric in long direction of building foundations — roll out, cut to length, flatten fabric outside of forms; position in lengths starting at one side; overlap preceding width one mesh +2"; tie at laps on 4" intervals

Note: Exercise caution not to damage earthen excavation walls; puncture or tear moisture barrier

CHECK POINTS: All reinforcement properly set, tied, secure

INSTRUCTOR'S PLAN
INFORMATIONAL LESSON

II-G-1(I)

SUBJECT:	Cement/Concrete
AIM:	The student will develop a greater awareness of the building material "concrete" and its allied industries; how cement is made; the versatility and many applications of cement and concrete in the construction industry.
TEACHING AIDS:	Chalkboard; Information Sheet II-G-1(IS), classroom bulletin and display board
MATERIALS:	Chalk
REFERENCES:	Concrete Technology, Units 1, 2, 3, 4 Methods And Materials of Commercial Construction, Unit 5 The World of Construction, Units 40, 41
PREREQUISITE EXPERIENCE OF THE LEARNER:	The student must have successfully completed lessons: I-B-1(I), School Policies and Procedures I-B-2(I), Shop Rules and Regulations I-D-1(I), Personal and General Shop Safety Complete and sign "Student Safety Pledge" Complete and obtain parent signature, "Parental Permit Form" Complete student personal data/private physician card Continue to exhibit sincere desire to learn building trades.

I. PREPARATION (OF THE LEARNER - MOTIVATION)

Facts:

1. Concrete is the most widely used building material in the world.
2. Concrete is the most versatile of all construction materials.
3. Concrete is one of the most durable of all construction materials.
4. Concrete is one of the oldest of all construction materials.
5. Concrete is one of the most economical construction materials for purposes for which it is used.
6. Concrete is a mixture of cement, water, and aggregates(sand, gravel, crushed rock) in given proportions.
7. Concrete is the only material brought onto a construction site that can have its physical properties changed on the job.
8. The more construction people know about concrete the better for the entire construction industry.

II. PRESENTATION (OF THE INFORMATION)

	INSTRUCTIONAL TOPICS TEACHING POINTS	THINGS FOR STUDENTS TO DO THINGS FOR INSTRUCTOR TO DO OR SAY
A.	Portland Cement	1. Is a finely ground material of mineral origin 2. Consists primarily of compounds of lime, silica, alumina, and iron 3. Mixed with water forms a workable paste which may be cast or molded 4. Hardens due to chemical reaction between cement and water called "hydration" 5. With aggregates added to mix, forms a hard, durable, economical mass called "concrete"
B.	History	1. Extends back to prehistoric times a. People abandoned caves - started to build shelters b. First problem - find a material to chink the stones and keep out the cold 2. Assyrians and Babylonians used certain clays for this purpose 3. Egyptians discovered lime-gypsum mortar; used in building pyramids 4. Greeks made further improvements 5. Romans perfected a cement that produced structures of amazing durability Examples: Colosseum System of Aquaducts 6. Despite early use, little was known of the chemistry of cement
	1. John Smeaton	1. Discovered that when limestone and clay were mixed and burned, the mixture hardened under water as well as in air a. While building a lighthouse in the English Channel b. In 1756 2. All present day portland cements possess this ability and are termed "hydraulic". This means they set and harden under water
	2. Joseph Aspdin	1. Patented process for manufacture of improved cement a. In England b. In 1824

2. Process consisted of:
   - a. Heating mixture of limestone and clay
   - b. Crushing resulting product to a fine powder
3. Called product portland cement because its color resembled stone quarried on the Isle of Portland, England
4. Is recognized as the father of the modern portland cement industry

3. Portland Cement In North America

1. Began with construction of first cement plant
   - a. In Coplay, Pennsylvania
   - b. In 1872
2. Has become a highly technological industry today
3. Formulas(ingredients and proportions) may be varied to produce varying types, characteristics, and qualities of concrete

C. Raw Materials

1. For portland cement are mined/quarried from certain mineral deposits
2. Are grouped to indicate component supplied by each group
   - a. Calcareous group - supplies lime component
   - b. Siliceous group - supplies silica component
   - c. Argillaceous group - supplies alumina component
   - d. Ferriferous group - supplies iron component
3. Major sources
   - a. Limestone - to include all carbonate rock containing large quantities of calcium
   - b. Cement rock - a low magnesium limestone containing clay
   - c. Earthy marls - friable accumulations of calcareous materials deposited by plants and animals over centuries in lake and marsh beds
   - d. Shell marls - fossil shells; varying amounts of clay and sand
4. Consists of proper combination of the following compounds
   - a. Lime

   b. Silica
   c. Alumina
   d. Iron oxide
   e. Gypsum

D. Manufacture

1. Closely controlled processes
2. Blend proper proportions of mineral compounds
   a. Limestone, marl, other calcareous material
   b. With clay, shale, blast furnace slag
3. Heated in rotary kilns to 2700°F
   a. Forms porous mass
   b. Mass called "clinker"
4. Clinker cooled and pulverized to a fine powder
5. Small amount of gypsum added to regulate setting time
6. Powder passed through 200-mesh sieve (40,000 openings per square inch)
7. Resulting product called "portland cement"

E. Packaging and Storage

1. Large users ship and store "in bulk"
   a. Special hopper cars; trucks
   b. Large silos, hoppers, special handling equipment
2. Packaged and sold by the bag
   a. 1 bag holds 1 cu. ft. of cement
   b. Bag of cement weighs 94 lbs.
   c. Bag of masonry cement weighs 70 lbs.
3. Packaged and sold by the barrel
   a. 1 barrel 4 bags(4 cu. ft.)
   b. 1 barrel weighs 376 lbs.

   NOTE: Portland cement will retain its cementing qualities indefinitely if it does not come in contact with moisture
4. Store in as dry and airtight a location as possible
   a. Store out of weather-in enclosed shed
   b. Do not store on concrete floor or against concrete wall
   c. Cover with tarp
5. "Warehouse pack"
   a. Occurs when bagged cement is stored for long periods
   b. Means cement packed in a particular

shape holds that shape in normal handling
- c. Problem usually corrrcted by rolling bag on floor
- d. Do not use if it has lumps that will not readily break up and become free flowing

F. Classifications
Passout: II-G-1(IS)

NOTE: Following are ASTM standard specifications

1. C150 Portland Cement, Types I through V
    - a. Type I - general purpose
    - b. Type II - modified, improved resistance to sulfates
    - c. Type III - high early strength
    - d. Type IV - low heat of hydration, used in large massive structures
    - e. Type V - sulfate resistant
2. C175 Portland Air-Entrained Cement
3. C205 Portland Blast-Furnace Slag Cement
4. C340 Portland Pozzolan Cement
5. Discuss classifications, characteristics, major uses as per information sheet

G. Related Occupations

1. Cement manufacturing
    - a. Quarrying raw materials
    - b. Handling bulk materials
    - c. Processing
    - d. Packaging, bagging
    - e. Transportation, storage
    - f. Other (list) engineers, management, sales, maintenance
2. Ready-mix Concrete Industry (batching plants)
    - a. Owner, manager
    - b. Laboratory and quality control technician
    - c. Plant Engineer, procurement
    - d. Batch control operator
    - e. Concrete truck driver
    - f. Sales representative
    - g. Other (list)
3. Construction Industry
    - a. Architect
    - b. Contractor
    - c. Construction superintendent
    - d. Estimaters
    - e. Concrete workers
    - f. Paving train operators

g. Cement finishers
h. Inspectors
i. Other(list) form construction, etc.

4. Precast Concrete Industry - manufactures and installs:
   a. Structural beams, columns
   b. Wall panels
   c. Roof and floor systems
   d. Concrete pipe, silos, water and septic tanks
   e. Other(list)
5. Concrete Masonry and Products Industry manufactures:
   a. Concrete masonry blocks (several kinds)
   b. Drain tiles and pipe
   c. Roof tiles
   d. Decorative concrete masonry
   e. Telephone conduit
   f. Manhole units
   g. Other(list) garden fixtures
6. Allied Industries
   a. Materials handling equipment manufacturers
   b. Transportation industry
   c. Tool and equipment
   d. Sand and gravel suppliers
   e. Concrete form companies
   f. Finishing tool manufacturers
   g. Other(list)

III. APPLICATION (DRILL, ILLUSTRATIONS, ANALOGIES, ORAL QUESTIONS OR ASSIGNMENTS, MAKING INVESTIGATIONS OR EXPERIMENTS, NOTE TAKING, MAKING SKETCHES, PARTICIPATING IN DISCUSSION.)

Class Discussion:

1. Various allied/associated industries of cement and concrete
2. Why these industries must be knowledgeable of cement; of concrete
3. Job opportunities in fields of, or relating to cement/concrete

Assignments:

1. Have student(s) obtain samples of the raw materials that go into the making of cement.
2. Have a student obtain a cement clinker.
3. Have student(s) make a collage of cement/concrete products and applications.

III. APPLICATION (CON'T.)

4. Have student(s) report on various "allied/associated" industries of cement(to include job opportunities).
5. Have student(s) obtain sample of "smaller cement/concrete product".

IV. VERIFICATION AND/OR EVALUATION (FINAL CHECK ON STUDENT'S COMPREHENSION OF MATERIALS PRESENTED.)

Oral Questions:

1. What is portland cement?
   Answer: Portland cement is a finely ground building material of mineral origin, mixed with water forms a pliable paste that can be cast/molded to shape, then hardens into a strong, solid mass due to a chemical reaction between the cement and water called hydration.

2. What are the primary ingredients(materials) that go into making portland cement? (name 5)
   Answer: lime, silica, alumina, iron oxide, gypsum

3. Who discovered and first used lime-gypsum cement mortar?
   Answer: Egyptians

4. What was John Smeaton's discovery?
   Answer: John Smeaton discovered that when limestone and clay are mixed and burned the mixture will harden under water as well as in air.

5. What term is applied to a cement with the ability to harden under water?
   Answer: "Hydraulic"

6. Briefly describe the process of making portland cement.
   Answer: Portland cement is made from carefully selected limestone, shell, and clay marls having high content of calcareous materials. The raw material is crushed, mixed in proper proportions and fed into rotary kilns where it is burned at 2700°F to form a porous mass called "clinkers". The clinkers are cooled and pulverized, gypsum is added to regulate setting time, and mixture is ground into a fine powder that will pass through a 200-mesh sieve.

7. How and in what quantities is portland cement packaged?
   Answer:
   1. By the bag - 1 bag = 1 cu. ft., 94 lbs.
   2. By the barrel - 1 barrel = 4 cu. ft., 376 lbs.
   3. By bulk - weight and volume

8. What is "warehouse pack"? How can it be corrected?
   Answer: Occurs when bagged cement is stored for long periods. Bags of cement take and hold the set(position) in which they are stored during normal handling. Can usually be corrected by rolling bag on floor.

IV. VERIFICATION (CON'T.)

9. What is the key to storing cement?
   Answer: Keep dry! Keep from coning in contact with moisture.

10. What is meant by "high early" cement?
    Answer: High early cement is a type cement which takes initial set and gains early strength in a shorter period of time.

V. SUMMARY (GIVE A BRIEF ACCOUNT OF EACH TOPIC REEMPHASIZING THE IMPORTANT POINTS. THIS SUMMARY MAY BE GIVEN AT ANY PLACE IN THE LESSON THE TEACHER FEELS WILL BE PROFITABLE TO THE STUDENT.)

Concrete/cement is one of the oldest, most versatile and widely used building materials in the world today.

This is so due to the fact that it is worked while in a plastic state, is easy to mold into a desirable shape, and hardens to a solid mass of amazing compressive strength.

Basic portland cement is made from lime silica, alumina, and iron oxide, crushed and mixed in the right proportions and burned in rotary kilns forming clinkers. The clinkers are ground into a fine powder along with some gypsum that will pass through a 200-mesh screen.

Portland cement mixed with aggregates (sand, gravel, other) and water forms concrete. There are several classifications and types of cement, and many ratios of mix to produce concretes with desirable characteristics for practically every application and circumstance.

The cement, concrete, and allied industries are vast and offer many job opportunities for individuals with knowledge of this building material.

SUGGESTED READINGS FOR THE STUDENTS:

The World of Construction, pp. 226-230
Concrete Technology, pp. 16-22

THE NEXT LESSON IS: II-G-2(I), "Concrete Mixes and Mixing"

INFORMATION SHEET

ON

TYPES OF PORTLAND CEMENT

SUBJECT: ASTM Classifications, Characteristics, and Major Uses of Portland Cement

INTRODUCTORY INFORMATION:

The portland cement industry in the United States today is a vast network of independent cement manufacturing firms. Each manufacturer makes portland cement. Portland cement is a type of cement, not a brand name.

The quality, or characteristic, that distinguishes portland cements is, "all portland cements are hydraulic". This means they will set and harden under water. Since this discovery by John Smeaton in 1756, the uses of portland cement have constantly expanded, expanding cement/concrete technology right along with it until today the American Society for Testing and Materials has identified the types and established standard specifications for each.

GENERAL INFORMATION:

Portland cements must meet one of the following:
ASTM Designation C150 - general purpose cement. Specifications come in five types:

Type I - General purpose; not requiring special properties; used where heat of hydration is not objectionable.

Uses: Pavement, sidewalks, bridges, railway structures, tanks, reservoirs, sewers, culverts, precast cement products, cement masonry.

Type II - Modified; has lower heat of hydration; has improved resistance to sulfate attack.

Uses: Large, heavy structures such as large piers, heavy abutments, and heavy retaining walls.

Type III - High early strength; used where high strength is desired at an early period of cure.

Uses: Where form removal at an earlier period is desirable; prestressed structural concrete forms; precast concrete products; home foundations (cuts construction time) and cold weather pours (reduces necessary period of protection against low temperatures).

Type IV - Low heat of hydration; produces lower amount and rate of heat generated during curing time; development of strength is also at a slower rate.

Uses: Types of construction where large masses of concrete are placed, gravity dams, massive foundations.

Type V - Sulfate resistant; resists chemical action of sulfates; has slower rate of strength gain than type I.

Uses: Used in construction exposed to severe sulfate action, such as in some western states where soil and water have a high alkali content.

Note: Types IV and V are generally available by special order only.

ASTM Designation C175 - air-entraining cement.

Has air-entrained materials incorporated in its manufacture. Causes minute, well distributed air pockets throughout cement paste. Makes cement/concrete more resistant to freeze-thaw action, more workable, more sulfate resistant, abrasion resistant, and watertight.

Types - Specified as type IA, IIA, and IIIA, which correspond respectively with types I, II, and III.

Uses: Uses are the same as types I, II, III only in areas where it is subject to severe freeze-thaw action.

ASTM Designation C205 - blast-furnace slag cement.

Select quality blast-furnace slag is interground with cement clinker.

Types - Divided into two types. Type IS, portland blast-furnace slag cement; Type IS-A, portland air-entrained blast-furnace cement.

Uses: Used for same applications as type I or type IA portland cement.

ASTM Designation C340 - pozzolan cement. Pozzolan, such as volcanic ash and/or rock, blended and ground with portland clinkers during manufacture.

Types - Two! Type IP, portland-pozzolan cement; Type IP-A, air-entraining portland-pozzolan cement.

Uses: Used largely for underwater structures such as dams and bridge piers.

Special Cements (Usually must be specially ordered.)

White cements - are manufactured from select raw materials to produce the white color.

Types - I, II, III, IA, IIA, IIIA, IP, IP-A.

Uses: Primarily architectural purposes; pre-cast walls, facing panels, decorative columns, terrazzo surfaces, stucco, tile grout, and cement paints.

Expansive cement - has ability to expand slightly during early hardening period after concrete takes set -- used to compensate for shrinkage which occurs as concrete dries.

Types - Three types K, M, S recognized.

Uses: Experimental applications in pre-stressed concrete industry. No large scale commercial use.

Regulated-set cement - setting time controlled in its formulation.

Types - Same composition as normal portland cements except for addition of component(s) responsible for early (rapid) compressive strength development - 1,500 psi @ 2 hrs; 3,000 psi @ 4 hrs.

Uses: Roadway pavement repair, insulating roof decks.

Oil-Well cements - slow setting, high resistance to pressure and heat -- different well depths.

Types - Specifications establish by API (American Petroleum Institute) standard 10A.

Uses: Various phases of oil well drilling operations.

Waterproofed cements - made by adding small amounts of calcium, aluminum, or other stearates to portland cement clinker during final grinding.

Types - Same as most ASTM types of portland cement.
Uses: Water retainers/containers, swimming pools, water cisterns, water reservoirs.

Plastic cements - made by adding up to 12% of volume, plasticizing agent to types I and II portland cement.

Types - I and II
Uses: Mortar, plaster, stucco.

INSTRUCTOR'S PLAN
INFORMATIONAL LESSON

SUBJECT:	Concrete Mixes and Mixing
AIM:	The student(s) will be able to calculate required amounts, types, and quality concrete that, once placed and finished, economically fulfills the job for which it was intended.
TEACHING AIDS:	Information Sheet II-G-2(IS); mold for slump test, 5/8" dia. rod, 6' folding rule; set of standard sieves
MATERIALS:	Samples: coarse and fine aggregates (gravel, crushed stone) Samples: dry, damp, wet, very wet sand
REFERENCES:	Concrete Technology, Units 5, 6, 7, 8, 9, 10 The World of Construction, pp. 226-230 Methods And Materials of Commercial Construction, Unit 5
PREREQUISITE EXPERIENCE OF THE LEARNER:	The student must have successfully completed previous lesson II-G-1(I), "Cement/Concrete". The student must further continue to display a sincere, positive attitude toward learning the building trades.

I. PREPARATION (OF THE LEARNER - MOTIVATION)

Concrete is the most versatile of all building materials. This statement is true only if the concrete is of good quality. Good quality meaning, "once it is mixed, placed and finished, it does the work it is designed to do". Quality concrete results when the proper materials are correctly proportioned, mixed, placed, finished, and cured for that specific job.

The above statements bear out the fact that, along with today's concrete technology, the worker must know more of the theory involved in order to do a better job working with concrete and its many applications.

If the worker and the engineer both do a good job in the office and the field, concrete can not only compete with steel and other building materials, but forge ahead to become the building material of the future.

II. PRESENTATION (OF THE INFORMATION)

INSTRUCTIONAL TOPICS TEACHING POINTS	THINGS FOR STUDENTS TO DO THINGS FOR INSTRUCTOR TO DO OR SAY
A. Concrete	1. Is composed of cement, water, and aggregates such as sand and gravel 2. Is a mixture in which a paste of portland and water binds fine and coarse aggregates into a rock-like mass as it hardens

3. Hardens through the chemical action of cement and the water called hydration
4. Strength is determined by basic relationship of cement to water
   a. Generally, the less water in the mix the stronger, more durable the concrete
   b. The mix must be workable - not so stiff it cannot be used
5. Properly cured, develops strength with age
6. Normal weight of concrete is 140-160 lbs. per cubic foot

B. Terminology

1. Strength - the choice of a water/cement ratio fixes the strength
2. Consistency - an indication of the amount of mixing water in relation to the amount of dry material
   a. Stiff consistency - one in which the amount of water is small and barely holds the cement and aggregate together
   b. Medium consistency - one that has a little more water than dry consistency
   c. Wet consistency - one that has much more water than dry consistency
3. Workable - variable term - concrete that may be workable for highways may not be workable for structures. Means "the concrete can be placed easily in some desired shape or location"
4. Slump test - a standard test for consistency; indicates degree of wetness and workability (will be discussed later in the lesson!)
5. Batch - one mixing, whatever quantity or size, of concrete

C. Materials

1. Concrete is composed of cement, water, and aggregates such as sand and gravel
2. The quality of materials used affects the quality of concrete produced

1. Cement

1. Portland cement - five basic types
   a. Type I - general purpose
   b. Type II - modified
   c. Type III - high early strength
   d. Type IV - low heat of hydration
   e. Type V - sulfate resistant

   Note: Review Lesson II-G-1(I)
2. Selection based on service; conditions

2. Water

1. Comprises approximately 21% of the total volume of concrete (28 to 42 gal. per cu. yd.)
2. Principal functions
   - a. To cause hydration of cement
   - b. To control consistency - excess of hydration makes possible the use of more aggregates to produce a more economical, workable paste
3. Should be relatively free of chemicals, impurities, algae
4. Rule-of-thumb - any natural water that is potable (drinkable) is satisfactory for mixing concrete

3. Aggregates

1. Comprise 65 to 75% of total volume of concrete
2. Most commonly used are sand, gravel, and crushed stone
3. Size (two categories)
   - a. Fine aggregates - sand; fine gravel
   - b. Coarse aggregates - coarse gravel, crushed rock
4. Gradation determined by sieve analysis
   - a. Fine aggregate - 1/4" to those small enough to pass through a sieve having 100 openings per square inch
   - b. Coarse aggregate - from 1/4" up to maximum size permitted for the job

   Note: Shows samples of sieves and graded aggregates
5. Maximum size (Guidelines)
   - a. One-fifth the dimension of non-reinforced members
   - b. Three-fourths the clear space between rebars or rebar and form
   - c. One-third the depth of non-reinforced slabs on grade
6. Good characteristics sought
   - a. Clean enough to permit cement paste to bond
   - b. Free of organic impurities to permit cement to set and harden
   - c. Tough enough to stand up under heavy loads, impact, shock, wear, and abrasion
   - d. Good particle shape and size

D. Design Considerations

Note: The design of a concrete mixture involves the determination of the most economical and practical combination of ingredients to produce a concrete that is workable in its plastic state that will develop the required qualities when hardened

1. Service
   - a. What it is supposed to do; where it is supposed to do it
   - b. Qualities required of hardened concrete

   Examples: 1. Resistance to freezing/thawing
   2. Watertightness
   3. Wear resistant
   4. Strength
2. Economy
   - a. Method and length of curing time
   - b. Workability - amount of work required to place, consolidate, and finish concrete
   - c. Consistency - best proportions to mix to minimize cost without sacrificing quality

E. Proportions

1. The ratio of coarse and fine aggregates to cement paste is important to produce a dense, workable, and economical concrete
2. The cement paste must completely surround and bind each particle of aggregate into a solid mass
3. There is less surface area to surround in a volume of coarse aggregate than in the same volume of fine aggregate
4. The finer aggregates are used to fill voids in the coarser aggregates
5. Hence the reason for use of more coarse aggregate
   - a. Less surface area for paste to cover
   - b. Less water required in cement paste
   - c. Produces a stronger concrete
6. Material quantities for concrete are specified by proportion in the form of a ratio:

   Example: A 1:2:3 mix would mean:
   One part cement
   Two parts sand
   Three parts gravel
7. The parts; or units of measure may be by weight or volume
8. Water is added to produce a good concrete workable mix
   - a. One that will place and finish well

b. One not so stiff that it crumbles

c. One not so soupy that aggregates separate and settle

d. Should be thick and creamy and sticky when worked with a shovel

Passout: II-G-2(IS)
Discuss

9. Years of experimenting have produced the following general mixes when using 1 1/2" maximum aggregate size

a. 5 gal. of water in a 1:1 3/4 :3 mix will produce satisfactory concrete for work subject to severe wear, weather, or weak acid and alkali solutions

b. 6 gal. of water in a 1:2 1/4 :3 1/2 mix will produce a concrete that is watertight and satisfactory for moderate wear and weather

c. 7 gal. of water in a 1:2 3/4:4 mix will produce concrete suitable where not subject to wear, weather, or water pressure

F. Trial Mix

1. Select specification to produce desired mix

2. Measure reduced quantitites to exact proportions in accordance with specifications

Example: 1/4 of a 5 gal. mixture are:
5 qts. water
1/4 cu. ft. cement
1/2 cu. ft. fine aggregate
3/4 cu. ft. coarse aggregate

3. Mix trial batch by hand

a. Mix sand and cement dry

b. Add coarse aggregate and mix again

c. Form a mound with a crater and add mixing water

d. Allow water to absorb into mound and mix until completely blended

Note: Plastic concrete should have a rich creamy consistency like a thick milk shake and should be sticky to shovel or hoe

G. Slump Test

1. Is a standard test for consistency

a. Shows degree of wetness or stiffness

b. Indicates whether concrete is workable

2. To perform test:

a. Place conical metal form on flat surface with large end down

b. While holding in place, fill cone one-fourth its height with trial mix concrete

c. Puddle mix with 25 strokes of a 5/8" rod
d. Complete filling cone in two more layers rodding each layer 25 strokes

Note: Do not let rod pass through to layers below

e. Strike off top so cone is exactly full
f. Remove mold immediately by giving slight twist and raising vertically
g. Place mold next to concrete mound and place rod across top of mold and mound
h. Measure from rod to top of mound for slump

3. Recommended slumps for concrete
   a. Massive sections; pavements and floors laid on ground....1" min. - 4" max.
   b. Heavy slabs, beams, or walls; tank walls; posts....3" min. - 6" max.
   c. Thin walls and columns; ordinary slabs or beams; vases....4" min. - 8" max.

Note: If specified proportions do not make a workable mixture, change the proportions of sand and gravel slightly. Do not change the amount of water

H. Specifying Ready Mix

1. The purchaser assumes the responsibility for the design
2. The purchaser must specify:
   a. Quantity - cubic yards
   b. Type of cement - see lesson II-G-1(I)
   c. Size of the coarse aggregate - maximum
   d. Water content - maximum allowable in gallons per bag of cement
   e. Desired slump - at point of delivery
3. The purchaser should also consider
   a. Time of delivery
   b. Temperature (weather) at delivery
   c. Manpower at time of delivery
   d. Preparation to receive concrete (forms, moisture barrier, reinforcement, screeds, finishing)
   e. Method of curing

I. Figuring Volume

1. Volume considered is that space inside the forms to be filled with concrete
2. Volume must be figured to determine quantities of concrete required
3. Volume is generally computed by figuring the area x depth

II. PRESENTATION (CON'T.)

4. Answer must be converted to cubic yards as concrete is purchased and delivered by the cubic yard

Passout: II-G-2(IS)

5. Discuss/explain use of tables and charts
    a. What chart is; what it does
    b. How to read charts; how to combine available information in problem solving
6. Discuss mensuration of volume formulas with class
7. Demonstrate on chalkboard
    a. Problems solving volume
    b. Geometric figures
    c. Formulas for areas; volumes

III. APPLICATION (DRILL, ILLUSTRATIONS, ANALOGIES, ORAL QUESTIONS OR ASSIGNMENTS, MAKING INVESTIGATIONS OR EXPERIMENTS, NOTE TAKING, MAKING SKETCHES, PARTICIPATING IN DISCUSSION.)

Assignment Sheet II-G-2(AS)

Passout: Have students complete assignment and return for grade

Field Trip! Concrete Batching Plant

Preview trip:
- Explain purpose and function of trip!
- Tell students what to look for!
- Review personal/group conduct; safety.
- List time schedule on chalkboard.
- Make individual student assignments to report on various phases of batch plant operations.
- Pass out parental permission slips (must be signed by parent).

Discuss trip:
- Overall batch plant operation
- Different jobs involved
- Duties and responsibilities
- Organization and management
- Services rendered

__Note__: Work individual student reports into discussion

IV. VERIFICATION AND/OR EVALUATION (FINAL CHECK ON STUDENT'S COMPREHENSION OF MATERIALS PRESENTED.)

Simple Recall:

1. Concrete is a mixture of cement, water, and _____. aggregates
2. Concrete hardens into a rock-like mass due to a chemical reaction called _____. hydration

IV. VERIFICATION (CON'T.)

3. The ____ of plastic concrete is an indication of the amount of mixing water in relation to the amount of dry material.	consistency
4. A plastic concrete in which the amount of water barely holds the cement and aggregates together is referred to as a ___ mix.	stiff
5. Generally the less ____ in a concrete mix, the stronger, more durable the concrete.	water
6. The key to quality concrete is that the mix be ____ and the hardened concrete perform the job intended.	workable
7. The standard test for consistency is the _____ test.	slump
8. Water satisfactory for mixing concrete should be _____.	potable
9. A sack of portland cement weighs _____ pounds.	94
10. By volume, one sack of portland cement equals _____.	1 cu. ft.
11. Characteristics sought in concrete aggregates are that they be _____, tough, and have good particle size and shape.	clean
12. Major design considerations of a concrete mix are service and _____.	economics
13. A 1:2:3 concrete mix would mean one part ____, two parts _____, and three parts _____.	cement sand gravel
14. One gallon of water weighs _____ pounds.	8.35
15. A 6 gal. paste means six gallons of water should be added per each _____ of cement.	sack
16. One cubic foot of water equals approximately ____ gallons.	7 1/2
17. The formula for the area of a triangle is a _____.	base x $\frac{1}{2}$ height
18. A U.S. short ton equals _____ pounds.	2,000
19. One cubic yard of concrete would pour a 4" thick slab of _____ square feet.	81
20. Concrete is ordered by the _____.	cubic yard

V. SUMMARY (GIVE A BRIEF ACCOUNT OF EACH TOPIC REEMPHASIZING THE IMPORTANT POINTS. THIS SUMMARY MAY BE GIVEN AT ANY PLACE IN THE LESSON THE TEACHER FEELS WILL BE PROFITABLE TO THE STUDENT.)

*Concrete is one of the most versatile and widely used of all building materials.

*Concrete is a mixture of portland cement, water, and aggregates in specified proportions.

*By varying the proportions slightly, and selecting the appropriate type of portland cement, a wide variety of uses under greatly varying circumstances may be realized.

*The major design considerations of concrete are the type service and the economics. The key is to determine the most economical and practical combination of ingredients to produce a concrete that is workable in its plastic state, that will develop the required qualities when hardened.

*Modern technology in the manufacture of portland cement has developed several types of cement to meet different needs. Along with innumerable trials, tests, and records of concrete mixes for varying modern day applications, some excellent guidelines have evolved.

*Using these guidelines as a base, quality concrete can be mixed for practically every construction application.

*Steps in selecting a concrete mix for a specified job.

1. Consider the service and conditions
2. Select type portland cement best suited (see previous lesson)
3. Consider size and configuration
4. Select maximum aggregate size and type paste (see chart, this lesson)
5. Select desired slump, (see chart, this lesson)
6. Mix trial batch
7. Perform slump test
8. Adjust proportions of fine and coarse aggregates slightly to obtain desirable slump; workable paste

*Specifying ready-mix concrete from a batching plant, specify:

1. Quantity (in cubic yards)
2. Type of cement (from previous lesson)
3. Size of coarse aggregate (maximum)
4. Water content (max. allowable in gal. per bag of cement)
5. Desired slump (at point of delivery)

Example: 32 cu. yds.
portland C-150 type III, grey
3/4" max. size aggregate
6 gal. paste
3" - 6" slump @ point of delivery

SUGGESTED READING FOR THE STUDENTS:

The World of Construction, pp. 231-236
Modern Carpentry, pp. 101-110

THE NEXT LESSON IS: II-G-3(I), "Placing, Finishing, Curing Concrete"

INFORMATION SHEET
ON
MIXING CONCRETE

SUBJECT: Concrete Mixes

INTRODUCTORY INFORMATION:

Since John Smeaton's discovery in 1756 that cements can be made hydraulic, i.e., set and harden under water, the cement/concrete industry has steadily grown and expanded until today concrete is one of the most versatile and widely used of all building and construction materials.

Other factors lending to the popularity of concrete as a building material are:

1. Versatility - it is worked(placed) while in a semi-liquid or plastic state readily conforming to different shapes and configurations. It can also be made water-tight and lighter in weight by changing the material and mix specifications.
2. Strength - it is extremely strong in compression; when properly reinforced, will compete favorably with steel both strengthwise and economically as structural members.
3. Durability - it will not rust, corrode, or deteriorate -- is long lasting and practically maintenance free.

Along with the ever expanding and popular applications of concrete have come many technological advances, both in the manufacture of cement and in proportioning and mixing of concrete. The person working with concrete today must be much more knowledgeable than his predecessors to provide his customers with a mix that is economical yet workable and will develop the required qualities when hardened.

GENERAL INFORMATION:

The needs(popular demand), and the means(modern technology), have caused the portland cement industry to develop several types of portland cement to meet specific needs for widely varying applications. A review of Information Sheet II-G-1(IS) will aid in the selection of the most appropriate cement for use within a type or category of application.

Concrete is composed of cement, water, and aggregates such as sand and gravel. Concrete is simply a name for a mass of aggregates surrounded and held together by hardened portland cement. If the paste is strong and the aggregates hard, the concrete is strong. If the paste and aggregates are durable, the concrete is durable. The secret of strong, durable concrete starts with the selection and proportioning of materials.

Aggregates - comprise 65% - 75% of the total volume of concrete.

The most commonly used aggregates are sand, gravel, and crushed stone. The two classes of aggregate are "fine aggregate" and "coarse aggregate". Fine aggregate can be a mixture of fine and coarse sand, while coarse aggregate can be crushed stone or naturally formed particles called pebbles or gravel.

Aggregates should have good particle shape, rounded or oval - not elongated or jagged, and strong enough to stand up under heavy loads; clean enough to permit the cement paste to bond; hard enough to resist grinding action; free from organic impurities to permit setting and hardening of cement; and tough enough to withstand impact.

Size gradation is determined by sieve analysis, generally numbered 4, 8, 16, 30, 50, and 100 for fine aggregate and 6", 3", 1 1/2", 3/4", 3/8" for coarse aggregate. Gradation is important as it separates and sizes the aggregate for correct proportioning later. Maximum allowable size of aggregate is controlled by the configuration of the object into which the concrete is formed. The following guidelines should be observed:

1. One-fifth the minimum thickness of non-reinforced members
2. Three-fourths the clear space between rebar and forms
3. One-third thickness of reinforced slabs on grade

Water - comprises approximately 21% of total volume of concrete.

The purpose of using water with cement is to cause hydration of the cement. Mixing water should be free of algae, acids, alkali, and oil. In general, water that is potable - fit to drink - is suitable for mixing with cement.

The amount of water used is very important. The water/cement ratio fixes the strength of the cement paste and is a control of the consistency or workability of the consrete. If too much water is added the paste will become thin and will be weak when it hardens. If too little water is used the paste will be too stiff, not completely surrounding and binding together the aggregate, again making it weak. A good concrete mix is one whose cement paste has good binding qualities and will hold the particles of aggregate firmly together.

Proportioning

Innumerable trials, tests, and records of concrete mixes have produced basic guidelines for varying categories of concrete service. The following chart suggests proportions for cement/water ratio; fine/coarse aggregate, and maximum aggregate size of concrete mixes for various categories or kinds of work. Follow these simple rules:

1. Find the kind of work in the left column which most closely describes your application
2. Establish whether it requires a 5, 6, or 7 gal. paste
3. Determine maximum aggregate size - from drawings, plans, specifications
4. Select a trial mix based on steps 1, 2, and 3 above
5. Mix trial batch and perform slump test
   Note: When mixing by hand measure material portions accurately
6. Adjust proportions of fine and coarse aggregate slightly if necessary to obtain a workable mix

(see chart next page)

SUGGESTED PROPORTIONS OF WATER, CEMENT, AND AGGREGATES FOR VARIOUS KINDS OF CONCRETE WORK

KINDS OF WORK	ADD U.S. GAL. OF WATER TO EA. SACK BATCH IF SAND IS:			TRIAL MIXTURE			MATERIALS PER CU. YD./CONCRETE		
					AGGREGATES			AGGREGATES	
	VERY WET	WET	DAMP	CEMENT SACKS	FINE CU. FT.	COARSE CU. FT.	CEMENT SACKS	FINE CU. FT.	COARSE CU. FT.
5 GAL. PASTE – for concrete subject to severe wear, weather, or weak acids.									
Toppings for two-course work.	3¾	4	4½	1	1¾	3 max. size 1½	7¼	13	22
One-course industrial, creamery and dairy plant floors.	3½	4	4½	1	2	2¼ max. size 1½	8	16	18
Thin sections of dense, strong concrete.	3½	4	4½	1	2	1¾ max. size ⅜	9	18	16
6 GAL. PASTE – for concrete to be watertight or subjected to moderate wear and weather.									
Watertight floors as in industrial plants, dairy barns, basements, etc.	4¼	5	5½	1	2¼	3½ max. size 1½	6	13½	21
Watertight basement walls, all watertight concrete for storage tanks septic tanks swimming pools, etc.	4	4¾	5½	1	2½	2½ max. size ¾	6½	16½	16½
Concrete subject to moderate wear or frost such as walks, driveways, tennis courts, etc. Reinforced structural beams, columns, etc.	4	4¾	5½	1	2½	2 max. size ⅜	7½	18¾	15
7 GAL. PASTE – for concrete not subjected to wear, weather, or water.									
Foundation walls, footings, mass concrete, etc.	5	5½	6¼	1	2¼	4 max. size 1½	5¼	14¼	21
	4½	5½	6¼	1	3¼	3 max. size ¾	5½	18	16½
	4½	5½	6¼	1	3¼	2¼ max. size ⅜	6½	21	14¾

Quantities are estimated on wet aggregrates using trial mixes and medium consistencies (5 in. slump)
Quantities are approximate and will vary according to grading of aggregates and consistency of mix.
Change proportions of fine and coarse aggregates slightly as required to obtain workable mix.

RECOMMENDED SLUMPS FOR VARIOUS TYPES OF CONCRETE CONSTRUCTION

TYPE CONSTRUCTION	Slump in Inches	
	Max.	Min.
Reinforced foundation walls and footings	5	2
Plain footings, caissons, and substructure walls	4	1
Slabs, beams, reinforced walls	6	3
Building columns	6	3
Pavements	3	2
Heavy masses, dams, etc.	3	1

Slump Test

The slump test is a standard test for consistency. It measures the amount of wetness in concrete paste by measuring stiffness of a mix. A conical-shaped mold made of 16-gage galvanized metal, open at the top and bottom, is used in making the test. The mold is 12" high with a 4" diameter opening at the top and an 8" diameter opening at the bottom. To perform the test:

1. Place base of mold on a flat surface and hold in place
2. Fill mold approximately one-fourth full with trial mix(paste)
3. Puddle paste with 25 strokes of a 5/8" rod
4. Complete filling mold in two more layers; rod each 25 times, the rod not to pass through the layer below
5. Strike off the top of the mold to be exactly full
6. Remove mold immediately by giving a slight twist and lifting vertically
7. Place mold adjacent to concrete slump and lay 5/8" rod across the top mold and mound
8. Measure the slump from the bottom of the rod to the top of the slump

The slump should fall into a given range for a concrete mix intended for a specified application. (see chart on preceding page)

Ordering Ready-mix

The purchaser assumes the responsibility for the concrete design. When ordering the purchaser must specify:

1. Quantity - in cubic yards
2. Type of portland cement - if type is not specified, C-150, Type I - general purpose is assumed
3. Water content - maximum allowable in gal. per bag of cement
4. Size of coarse aggregate - maximum
5. Desired slump - at point of delivery
6. Time of delivery - approximate

Other factors to be considered by the purchaser are:

1. Preparations to receive concrete
    a. Forms ready
    b. Moisture barriers placed
    c. Reinforcement in position; tied
    d. Screeds, if required
2. Weather and temperature
3. Method and procedure of placement; finishing; curing
    a. Necessary manpower
    b. Necessary tools and equipment
    c. Necessary accessways

Figuring Volume

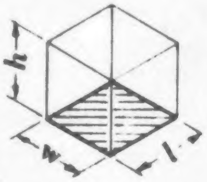
Volume to be considered in concrete work is "that space inside the form to be filled with concrete". Figuring volume is generally not difficult if a few simple rules are kept in mind.

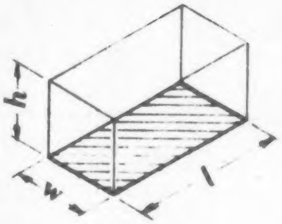
Area is a level surface within a given set of lines
Volume is a space occupied
Generally volume is a product of an area x a depth(height)

Examples:

Area of a square or rectangle:
$a = l \times w$

Volume of a square or rectangle:
$v = a \times h$



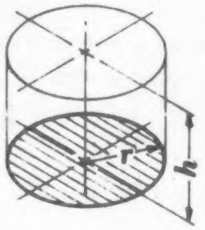


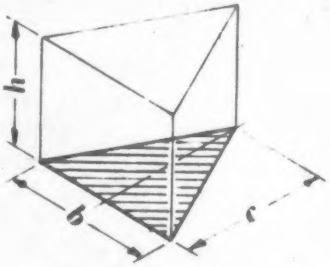
Area of a circle:
$a = \pi r^2$ $\pi = 3.1416$

Volume of a cylinder:
$v = a \times h$

Area of a triangle:
$a = 1/2\ b \times c$ (altitude)

Volume of wedge:
$v = a \times h$





The following charts show frequently used formulas, weights, measures, and quantity tables for commonly used concrete shapes. Study each and become familiar with their use and application.

NUMBER OF SQUARE FEET OF FLOOR from 1 Cu. Yd. of Concrete

Thickness Inches	No. of Sq. Ft.	Thickness Inches	No. of Sq. Ft.	Thickness Inches	No. of Sq. Ft.	Thickness Inches	No. of Sq. Ft.
2	162	5	65	8	40	11	29½
2½	130	5½	59	8½	38	11½	28
3	103	6	54	9	36	12	27
3½	93	6½	52	9½	34	12½	26
4	81	7	46	10	32		
4½	72	7½	43	10½	31		

CONCRETE COLUMN QUANTITIES (cu. yd. per 100 lin. ft.)

Size / Type	6"	8"	10"	12"	14"	16"	18"	20"	22"	24"
Round	0.74	1.28	2.02	2.82	3.96	5.12	6.55	8.08	9.70	11.28
Square	0.93	1.65	2.58	3.71	5.04	6.60	8.40	10.32	12.45	14.88
Octagon	0.77	1.37	2.14	3.08	4.18	5.48	7.92	8.56	10.40	12.32

CONCRETE BEAM QUANTITIES

(cu. yd. per 100 lin. ft.)

Width (Inches)	Depth (Inches)								
	8	10	12	14	16	18	20	22	24
6	1.24	1.55	1.86	2.17	2.48	2.79	3.10	3.41	3.72
8	1.64	2.05	2.46	3.07	3.28	3.69	4.10	4.51	3.92
10	2.05	2.56	3.08	3.60	4.10	4.61	5.12	5.64	6.16
12	2.46	3.08	3.72	4.33	4.96	5.54	6.16	6.80	7.44
14	2.88	3.60	4.32	5.04	5.76	6.48	7.20	7.92	8.64

FREQUENTLY USED FORMULAS

area of a square; rectangle = length X width
area of a triangle = base X ½ height
area of a trapezoid = sum of bases X ½ height
area of a circle = 3.1416 X radius squared

volume of a cube; rectangle = area of base X height
volume of a wedge = area of base X ½ height
volume of a cone; pyramid = area of base X ⅓ height
volume of a cylinder = area of base X height

AVOIRDUPOIS WEIGHTS

16 ounces = 1 pound
25 pounds = 1 quarter
4 quarters = 1 cwt.
2,000 pounds = 1 ton (short)
2,240 pounds = 1 ton (long)

LIQUID MEASURE

16 fluid oz. = 1 pint
2 pints = 1 quart
4 quarts = 1 gallon
31½ gallons = 1 barrel

LINEAR MEASURE

12 inches = 1 foot
3 foot = 1 yard
1,760 yd.s = 5,280 ft. = 1 mile

SQUARE MEASURE

144 sq. in. = 1 sq. ft.
9 sq. ft. = 1 sq. yd.
4,840 sq. yd.s = 43,560 sq. ft. = 1 acre
640 acres = 1 sq. mi.

CUBIC MEASURE

1,728 cu. in. = 1 cu. ft.
27 cu. ft. = 1 cu. yd.

FREQUENTLY USED CONVERSIONS

1 cu. ft. crushed stone = 100 lbs.
1 cu. ft. gravel = 95 lbs.
1 cu. ft. sand (dry) = 97-117 lbs.
1 cu. ft. sand (wet) = 120-140 lbs.
1 cu. ft. mortar = 103 lbs.
1 cu. ft. concrete = 140-160 lbs.
1 cu. ft. water = 62.5 lbs., 7.48 gal
1 cu. ft. cement = 94 lbs., 1 sack
1 gal. water = 8.35 lbs.

APPROXIMATE METRIC CONVERSIONS

1 centimeter = ⅜ inch
1 decimeter = 4 inches
1 meter = 1.1 yards
1 kilometer = ⅝ mile
1 liter = 1.06 quarts (liquid)
1 liter = 0.9 quart (dry)
1 kilogram = 2.2 pounds
1 metric ton = 2,200 pounds

287

ASSIGNMENT SHEET
IN
CONCRETE ESTIMATING

SUBJECT: Calculate type, volume, cost of concrete for jobs specified

AIM: The student will be able to calculate volume requirements of concrete in the preparation of cost estimates and/or ordering concrete.

INTRODUCTORY INFORMATION:

Concrete is ordered and purchased by the cubic yard. If too little concrete is ordered for a job, the original order must be placed upon delivery and additional concrete ordered. The time lapse between the first delivery and the second may cause a serious flaw or defect in the concrete object being formed. On the other hand, when too much concrete is ordered for a job, the excess is hauled off as waste but the contractor still pays for it. Either way, it behooves the person responsible for ordering concrete to calculate the requirements accurately and round off to the closest cubic yard above actual requirements.

REFERENCES: Information Sheet II-G-2(IS), "Estimating Concrete"

QUESTIONS OR ANSWERS:

1. Figure the number of cubic yards of concrete required to lay a sidewalk, 4" thick x 3 1/2' wide x 108 yards long.
   14 cu. yd.

2. Anchor blocks for a television tower's guidelines measure 4' x 4' x 10'. How much concrete (total) is required to form the four blocks?
   24 cu. yd.

3. How much concrete must be ordered for a 4" patio slab measuring 16' x 20'?
   4 cu. yd.

4. A foundation footing for a rectangular shaped building has cross-sectional dimensions of 12" x 24". The outside dimensions of the footing are 25' x 145'. How many cubic yards must be ordered to pour this footing?
   25 cu. yd.

5. A driveway made of concrete 6" thick, 18' wide, and 45' long will require how many cubic yards of concrete?
   15 cu. yd.

6. The city park wants a circular retainer wall for a flower garden. The wall is to be a 12" wall, 2' high, having a 60' outside diameter. How many cubic yards will be required to construct the wall?
   14 cu. yd.

7. The flower garden (problem 6) is to have 12 columns, 12" in diameter and 11'-4" tall equally spaced around the wall. How much concrete will be required to form these columns?

4 cu. yd.

8. How much concrete must be ordered for 100 linear feet of an 8" x 8'-0 foundation wall?

20 cu. yd.

9. A park wadding pond measures 40' in diameter outside and is 21" deep inside. The bottom is 4" thick and the walls are 8" thick. How much concrete is required?

21 cu. yd.

10. A monolithic slab and beam foundation measures 24' x 48'. The slab is 4" thick and the beam measures 8" x 22" below and around the perimeter of the slab. In addition, two beams of the same dimension run across the width of the slab at 16' intervals. What is the total concrete requirement for this foundation? (Make a sketch if necessary.)

19 cu. yd.

INSTRUCTOR'S PLAN
INFORMATIONAL LESSON

II-G-3(I)

SUBJECT:	Placing, Finishing, Curing Concrete
AIM:	The student(s) will be able to list, in proper sequence, the steps procedures for placing concrete and explain the purpose of following this procedure. The students will further be able to identify the tools used in working and finishing concrete and explain their proper use.
TEACHING AIDS:	Information Sheet II-G-3(IS) Hand finishing tools such as darby, bull float, hand floats, edger, jointer or groover, steel finishing trowel
MATERIALS:	None
REFERENCES:	The World Of Construction, pp. 231-241 Concrete Technology, pp. 71-89
PREREQUISITE EXPERIENCE OF THE LEARNER:	The student must have successfully have completed previous lessons II-G-1(I), and II-G-2(I). The student must continue to display a positive attitude to learning the building trades.

I. PREPARATION (OF THE LEARNER - MOTIVATION)

To this point, everything has been in preparation of receiving the concrete; excavations dug, sub-base prepared and compacted, forms erected, reinforcing steel set, and the concrete order made. We are now ready to place the concrete in the forms.

Concrete must be delivered to the job site and discharged from the truck within $1\frac{1}{2}$ hours from the time water is added to the mixture. In extremely hot weather, or in conditions which hasten the stiffening of the paste, this time is shortened. It is a good practice to place the concrete in the forms within 30 to 60 minutes after mixing. This means the site must be ready to receive the concrete and work must be organized and continuous until the concrete is placed and finished.

Allowable time, transportation of the concrete on the job, and the method of placing the concrete in the forms are the most important considerations in placing concrete. There are several methods used to move the concrete from the mixer to the forms and the method depends largely on the job conditions. The job should be thought out in advance; the method of transporting the concrete on the site determined; the procedure for placing the paste planned; and the equipment and manpower made available and ready to perform the work. Remember, the actual placing of concrete should be as close to its final position as possible. The old adage that "good concrete is placed, not poured" is still very true.

II. PRESENTATION (OF THE INFORMATION)

	INSTRUCTIONAL TOPICS TEACHING POINTS	THINGS FOR STUDENTS TO DO THINGS FOR INSTRUCTOR TO DO OR SAY
A.	Placement Methods	Note: Placing means "taking concrete from the mixer to its final place in the finished structure
	1. Direct Chuting Passout: II-G-3(IS)	1. Mixing trucks are equipped with discharge chutes 2. Discharge chutes can be pivoted to: a. Allow movement of chute end to guide placement of concrete b. Vary tilt of chute to aid control of flow 3. Discharge is by gravity flow 4. Used in flat pours or foundation forms where mixing trucks can be positioned
	2. Buggies or Wheelbarrows	1. May be hand pushed or power driven 2. Size varies from 3 cu. ft. to 1/3 cu. yd. 3. Still used extensively on smaller jobs 4. Runways are required for smooth operation over formwork and construction 5. Paste usually dispensed from hopper to buggies
	3. Buckets	1. Vary in size and shape a. Capacities from 1/3 to 12 cubic yards b. Cylindrical or rectangular c. Tapered at bottom to a discharge gate 2. Discharge gate a. May be hand or power operated b. Allows control of gravity discharge 3. Are loaded through open top via discharge chute of mixing truck 4. Are moved about by crain hoist or overhead cableway 5. Generally used on large and/or elevated jobs
	4. Belt Conveyors	1. Used to transport large quantities rapidly 2. Capable of delivering up to 120 cu. yds. per hour 3. Most commonly used are: a. Feed conveyors - used to transport concrete horizontally rapidly; 60-120 cu. ft. per hour b. Portable conveyors - used to transport concrete short distances up inclines to

30°; portable units can handle 40-80 cu. ft. per hour

c. Side discharge conveyors - used to lay large, flat areas; can handle up to 100 cu. ft. per hour

4. Belt conveyors are economical where large, massive pours are required

5. Pumping

1. Is the fastest growing method of placing concrete on large structures
2. Has an advantage in that it is pumped through a pipeline to a delivery point - pipeline can be laid over, around, construction obstacles
3. Can deliver concrete paste:
   a. Approximately 1200 ft. horizontally
   b. Approximately 200 ft. vertically
   c. At a rate of about 80 cu. yds. per hour
4. Pressures cause even flow of concrete which:
   a. Produces higher compressive strength, durability
   b. Reduces bleeding, surface faults

B. Placement Procedures

1. Are to prevent segregation of aggregates
2. Are to prevent honeycombing effect
3. Are to reduce overworking of concrete which may cause:
   a. Excessive bleeding - water and fine materials to surface
   b. Laitance - slimy mortar
   c. Scaling/dusting - thin weak layer of concrete
4. Dictate that concrete:
   a. Not be dropped freely more than 4 feet
   b. Be placed as close to its final position as possible

1. Pre-placement Check

1. Sub-grade should be:
   a. Cleaned
   b. Tamped
   c. Proper elevations
   d. Moistened to prevent mixing water needed for curing from being absorbed into soil
2. Forms should be:
   a. Tight, aligned, well-braced
   b. Proper elevation
   c. Insides clean of foreign matter and oiled or sealed for easy form removal
3. Reinforcement should be:
   a. Securely tied in place

- b. Free of rust, scale, oil or dried concrete

4. Screeds, if necessary:
   - a. In place
   - b. Level and/or parallel with tops of forms
5. Walkways and ramps:
   - a. Strong
   - b. Secure

2. Walls and Columns

1. Guide concrete into deep forms using an appropriate type adjustable chute
   Examples: Elephant trunk and tremie
   Rubber or plastic sleeve
2. Start at both ends of a wall and work toward the middle
3. Deposit concrete in level layers 12"-18" deep
4. Consolidate each layer before preceding to the next
5. Fill form completely after the last layer has been consolidated
6. When pouring concrete in the supports of slabs, beams, and girders - all concrete to stand at least 2 hours before commencing pour of slabs, beams, or girders

3. Slabs and Flat Pours

1. Start around perimeter at far end
   - a. Corners first
   - b. Work toward middle
2. Work from far to near end
   - a. Place each batch against previously placed concrete
   - b. Place concrete as close to its final position as possible

C. Consolidation

1. Provides a tighter, denser, stronger paste
2. Is the removal of voids (air pockets called honeycombs) and air bubbles from freshly placed concrete paste
3. May be performed while the paste is still being placed
4. Is generally accomplished by hand spading, jitterbugging, and vibration
5. Hand spading and jitterbugging are generally used on slabs and flat surfaces
   - a. Hand spading - performed by turning spade over and executing shallow chopping action over the surface area
   - b. Jitterbugging - performed with a

perforated-like tamping tool and a light jogging action over the surface area

6. Vibrators generally used in heavier foundations, walls, columns, beams
7. Vibrators make possible the use of stiffer, concrete pastes
8. Vibrators are of two major types:
   - a. Internal (spud) type vibrator
   - b. External (knocker) type vibrator

1. Spud Vibrators

1. Used primarily to consolidate slabs, beams, walls, and columns
2. May be powered by gasoline, air, or electricity
3. Unit consists of:
   - a. Power unit
   - b. Flexible stem
   - c. Vibrating head
4. Operation
   - a. Turn unit on
   - b. Immerse head of vibrator in the concrete paste
   - c. With a vertical down and up action
   - d. Slowly; 5-10 second cycle

   Note: Do not hold vibrator against re-bar
   - e. At regular intervals to consolidate the concrete

2. Knockers

1. Used primarily in narrow, heavily reinforced sections where internal vibrators cannot be used
2. Are also powered by gasoline, air, or electricity
3. Are a percussion tool
4. Are attached to outisde of forms
   - a. At intervals of 2-3 feet
   - b. Intervals are determined by the size knocker; type of form
5. Consolidation results by vibrating through the forms

   Note: Forms must be exceptionally sturdy and tight so that percussion of knockers will not cause damage or leakage. Forms are usually metal

D. Finishing

1. Is the treating of concrete surfaces to produce the desired surface texture and wearing qualities

2. Is required to some extent of all exposed concrete surfaces

1. Striking Off

1. Also called "screeding"
2. Is the first leveling operation
3. Removes the humps and hollows that result in placement
4. Provides overall true, even surface to the concrete
5. Is performed with a straight edge or strike-off board (describe - show example)
   - a. Actual strike-off tool is preferred
   - b. Straight 2" x 6" lumber, 1 or 2 feet longer than area being struck may be used
6. Strike-off procedure:
   - a. Move straight edge back and forth with a sawlike motion
   - b. Across the tops of the forms or screeds
   - c. Start at one end
   - d. Advance lead edge a short distance with each movement
   - e. Keep a small amount of concrete ahead of the straight edge to fill low spots and maintain surface plane
   - f. In some cases consolidation and striking-off are performed in a single operation by slightly jogging saw like action

   Note: Screeds are removed after strike-off when the surface is stiff but not hard. The grooves made by the screeds are patched and floated

2. Floating

1. Is the second leveling operation
2. Helps push larger aggregate down - bring sufficient mortar to the top
3. Eliminates minor ridges and voids left by strike-off operation
4. Is performed by several methods
5. Darby - (show one)
   - a. Large hand float 3"-4" wide x 4' long with elongated, tapered handle along top
   - b. Used on surfaces of moderate size that can be reached with a darby
   - c. Is used with large, gentle, sweeping strokes across the concrete surface
     - 1.) Lead edge of float raised slightly
     - 2.) Light pressure is applied to smooth and blend surface concrete

6. Bull Float - (show one)
   a. Large hand float 6"-8" wide x 4'-6' long with long (8'-12') handle attached to center back and extending to one side at about a 15° angle
   b. Performs the same function as a darby except on larger surfaces
   c. Used with long, gentle push/pull strokes
      1.) Lead edge of float raised slightly
      2.) Weight of float is generally sufficient to smooth and blend surface
7. Power Floats (show picture)
   a. May be gas or electric powered - looks and operates similar to a large floor buffer
   b. Performs same operations as hand float but covers larger areas faster
   c. Must be used after concrete is stiff enough to support operator's weight
8. Hand Floats - (show example)
   a. 3½" wide x 12"-16" long; wood or metal
   b. Used to float concrete around pipes, columns, in corners and areas where larger floats cannot be used

3. Edging

1. Is performed with a hand tool called an edger
   a. Several types: sizes (curved-end most commonly used)
   b. 6" long, vary in width 1½"-4"
   c. Radii of lip ranges 1/8"-1 1/2"
2. Produces a radius around the edge of slabs
3. Improves slab appearance
4. Reduces risk of chipping

4. Jointing

1. Is accomplished with a hand, or power tool Show: Samples
   a. Hand jointer
      1.) 6" long, 2"-4½" wide
      2.) Cutting edge (bit) centered below handle
      3.) Bits to cut joints 3/16"-1" deep
   b. Power jointer
      1.) Electric or gasoline driven
      2.) Resembles large skill saw with shatterproof abrasive blade
2. Cuts grooves 1/4 to 1/5 slab depth in an attempt to predetermine locations of possible

cracks
- a. Called control joints
- b. Also improves appearance of large slabs

3. Performed using straight edge as a guide

5. Troweling

1. Is accomplished using hand or power trowel
   Show: Samples
   - a. Hand Trowel
     - 1.) Steel blades 3"-4 3/4" wide, 10"-20" long
     - 2.) Available in a variety of sizes
   - b. Power Trowel
     - 1.) Powered by electricity or gasoline engine
     - 2.) Has 3 or 4 rotating steel trowel blades
     - 3.) Operates similar to a large floor buffer
2. Gives concrete a dense, smooth surface
3. Finish is slippery when wet

6. Other Finishes

1. List
2. Give examples

E. Curing

1. Of concrete is a chemical process between the cement and the water called "hydration"
2. Of concrete is generally a controlled process
3. Properly improves all desirable properties of concrete
   - a. Strength
   - b. Watertightness
   - c. Wear resistance
   - d. Volume stability
   - e. Durability - resistance to freeze-thaw
4. General requirements
   - a. Time - length of time concrete must be protected against loss of moisture
   - b. Favorable temperatures - (50^{o} - 90^{o}F) curing time depends on the temperature
   - c. Moisture - is essential for hydration - rapid water loss must be prevented - especially during the early stages of the curing process
5. Methods are of two (2) classifications
   - a. Those which prevent loss of moisture
   - b. Those which supply additional moisture
6. Methods should be applied only after concrete has hardened sufficiently to prevent

surface damage. Methods include:
- a. Watertight covers
- b. Chemical membranes
- c. Forms left in place
- d. Water retaining covers
- e. Sprinkling
- f. Ponding

1. Watertight Covers	1. Include: a. Waterproof paper b. Plastic films (polyethylene) c. Chemical membranes (sprayed) 2. Sheets should be: a. Wide as possible b. Seams overlapped several inches and sealed tightly with tape 3. Chemical compounds generally sprayed; form membrane over entire surface Note: Plastic and chemicals are available in clear and colored to reflect or absorb heat from sun - an additional control factor
2. Forms Left in Place	1. Provide some protection against loss of moisture 2. Usually used in conjunction with other methods 3. Should be kept moist in dry, hot weather
3. Water Retaining Covers	1. Include: a. Sand b. Straw c. Burlap 2. Exercise care to cover entire surface 3. Moisten periodically to maintain constant damp condition
4. Sprinkling	1. Continuous spray of water very effective 2. Fine mist is most effective 3. If done in intervals - exercise care that concrete does not dry out between applications
5. Ponding	1. Used on flat surfaces such as walks, pavements, floors 2. Most effective in preventing loss of moisture 3. Effective in controlling temperature in hot weather

4. Accomplished by building small dyke or dam around perimeter and flooding interior
5. Consider cost of labor involved this method

F. Safety

Note: Concrete paste, allowed to contact the skin or eyes can cause serious caustic burns

1. Wear appropriate safety apparel - when working in direct contact with paste, apparel should include:
    a. High top rubberized boots - tuck trousers
    b. Protective (rubberized) gloves
    c. Goggles, approved eye protection
2. Know locations of fresh water supply, water, curtain, shower, or hose
3. Wash clean immediately, any concrete paste which has saturated clothing or contacted skin
4. Practice appropriate ladder-scaffold safety when working on high forms, elevated areas
5. Apply proper technique in lifting, carrying heavy objects
6. Be alert in work areas where heavy, moving equipment is operating
7. Observe all general safety rules

III. APPLICATION (DRILL, ILLUSTRATIONS, ANALOGIES, ORAL QUESTIONS OR ASSIGNMENTS, MAKING INVESTIGATIONS OR EXPERIMENTS, NOTE TAKING, MAKING SKETCHES, PARTICIPATING IN DISCUSSION.)

Field Trip: To Large Construction Site In Process of Laying Foundation
Instructor: Arrange field trip - time, place, transportation, etc.
Review trip:
    Explain purpose and function of trip
    Tell students what to look for
    Review personal/group conduct; safety
    Make individual student assignments (oral reports on some phase of field trip)
    List time schedule on chalkboard
    Pass out Parental Permission Slips (must be signed by parent)
Take Trip!
Discuss Trip:
    Jobs, duties, responsibilities
    Procedures, techniques
    Tools, materials
    Note: Work student reports into class discussion

IV. VERIFICATION AND/OR ELEVATION (FINAL CHECK ON STUDENT'S COMPREHENSION OF MATERIALS PRESENTED.)

1. The three most important considerations for placing concrete are: allowable time, transportation of concrete on the job, and the ______.	method of placement
2. It is a good practice to place the concrete in the forms within ______ to ______ minutes after mixing.	30-60
3. The old adage, "good concrete is ______, not ______" is still very true.	placed, poured
4. Special requirements for a smooth operation when buggies or wheelbarrows are used to convey concrete on the site are ramps and ______.	runways
5. ______ are used to transport large quantities rapidly on a job site.	Belt conveyors
6. The fastest growing method of placing concrete on large structures is ______.	pumping
7. When placing concrete in deep forms, the concrete should not be dropped freely more than ______ feet.	4
8. When placing concrete in deep forms, deposit in level layers ______ to ______ deep and consolidate each layer.	12" - 18"
9. On slabs and flat pours, work should start at the ______ end and progress to the ______ end.	far - near
10. The first leveling operation is called ______ off.	striking
11. Additional boards placed inside the forms at the same elevation to aid in leveling are called ______.	screeds
12. A power operated vibrating tool composed of a vibrating head mounted on a flexible stem attached to a power unit, used to consolidate concrete is called a/an ______ vibrator.	spud
13. A large hand flat 3"-4" wide x 4" long with a long tapered handle on top is called a/an ______.	darby
14. ______ improves slab appearance and reduces risk of chipping.	Edging
15. ______ finish gives concrete a dense, smooth, surface.	Troweled

V. SUMMARY (GIVE A BRIEF ACCOUNT OF EACH TOPIC REEMPHASIZING THE IMPORTANT POINTS. THIS SUMMARY MAY BE GIVEN AT ANY PLACE IN THE LESSON THE TEACHER FEELS WILL BE PROFITABLE TO THE STUDENT.)

Allowable time, transportation of the concrete on the job, and the method of placing the concrete in the forms are the three major considerations in placing concrete.

Concrete must be delivered and discharged within $1\frac{1}{2}$ hours from the time water is added to the mixture. A good rule-of-thumb is to place the concrete within 60 minutes after mixing. This means the job site must be ready to receive the concrete and work continuously and in an organized manner until the concrete is placed and finished.

The job should be thought out in advance; the method of transporting the concrete on the site determined; the procedure for placing the concrete established; and the equipment and manpower available and ready to perform the work. A final check of the site should include: accessways for delivery trucks cleared; walks and ramps in place, if necessary; forms secure, tight, aligned, oiled for easy removal; reinforcement in place, tied.

There are several means of transporting concrete paste on the job. Direct chuting is used extensively where the mixer trucks can be positioned close enough to the forms to use gravity flow chutes. Wheelbarrows and/or buggies are often used on small jobs or to place concrete in areas where chutes will not reach. Large buckets moved about with crain hoists are used extensively in building construction with elevated forms. Belt conveyors transport large quantities rapidly over horizontal distances and are used on large massive pours. The fastest growing method is pumping. This has an advantage in that it is pumped through a pipeline that can be laid over, around other obstacles. Whatever means of transportation, the equipment should be checked to be adequate and in good working condition.

In placing concrete there are two general rules to keep in mind. One, concrete is placed, not poured; concrete paste should never drop freely more than 2-4 feet. Two, concrete should be placed as close to its final resting place as possible. In placing concrete deep forms such as wells and columns:

1. Guide concrete into forms using appropriate type adjustable chute
2. Start at both ends of the form and work toward the middle
3. Deposit concrete in level layers 12-18 inches deep
4. Fill form completely after last layer has been consolidated - if in support of slabs, beams, or girders, all concrete to stand 2 hours before commencing pour of slabs or beams.

In placing concrete in shallow flat forms - slab:

1. Start around perimeter at far end
2. Work progress from corners to middle; far end to near end
3. Place each batch against previously placed concrete
4. Place concrete as close to final position as possible.

Consolidation is the removal of voids and air pockets that may have been created in the handling and placing of concrete pastes. Consolidation is accomplished in one of three ways: spading, jitterbugging, and vibrating. Consolidation is generally performed between placement and finishing of concrete.

"Finishing" concrete is the treating of the surface to produce the desired surface texture and wearing qualities. All concrete surfaces require finishing to some extent. After the concrete is placed it is struck-off to remove all the humps and hollows that result in placement. Strike-off is performed with a straight edge, or strike-off board, placed across the tops of the forms and/or screeds (intermediate boards placed inside the forms at the same elevation for strike-off of large surfaces) and moved back and forth in a sawlike action while advancing board a short distance with each stroke. This provides an overall true, even surface to the concrete.

After strike-off, the screeds, if any, are removed and the holes patched. The concrete is now ready to float. There are several different types of tools (floats) for this purpose. Generally, the size and type job dictates the type float used. Power operated floats, similar to large floor buffers are used on large surfaces to cover the area in a short time. Power floats must be used after the concrete is stiff enough to support one's weight and cannot get in corners or close areas. Bull floats are used on moderately large surfaces in areas open enough to operate with its long handle. Darbies are often used on smaller slabs and in areas where bull floats are not functional. Hand floats are for working in corners and in confined areas. Floating eliminates minor ridges and voids left by the strike-off operation and while it may serve as a finish itself, it helps push larger aggregates down and bring sufficient mortar to the top for additional finishing operations. Other finishing techniques include edging, jointing, troweling, and texturing.

Concrete hardens by a chemical process between cement and water called hydration. If the water evaporates from concrete to rapidly, it will cause the concrete to check, crack, and otherwise be weakened. Curing is the prevention of too rapid a loss of moisture in concrete. There are two classifications of methods used to prevent this rapid loss of moisture: 1) those which prevent loss of moisture - this would include watertight covers and chemical membranes; and 2) those which supply additional moisture such as water retaining material covers, sprinkling, and ponding. Proper curing improves all desirable properties of concrete. The general requirements for proper curing are time, favorable temperatures, and moisture.

SUGGESTED READING FOR STUDENTS:

Concrete Technology, Units 12, 13, 14, 15

THE NEXT LESSON IS: III-A-1(I), "Sills And Girders"

INFORMATION SHEET
ON
WORKING CONCRETE

SUBJECT: Placing, Finishing, and Curing Concrete

INTRODUCTORY INFORMATION:

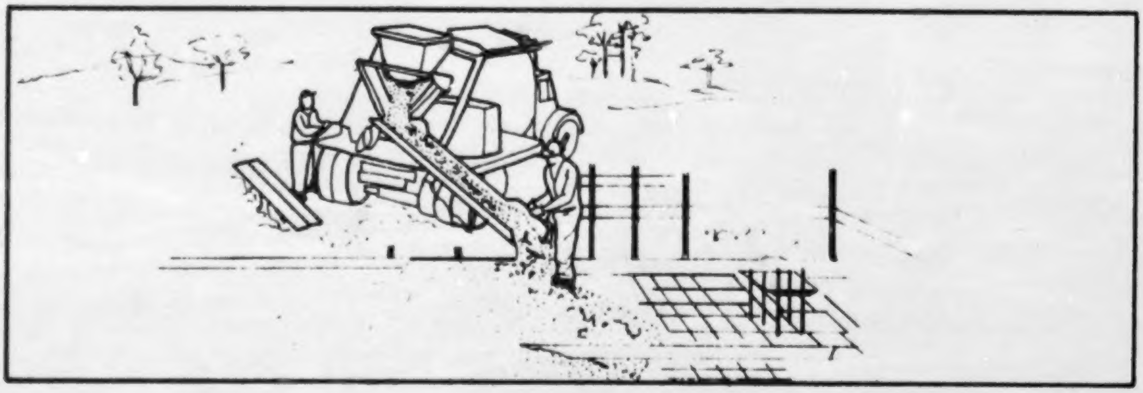
Concrete hardens due to a chemical process between water and cement. This process is called hydration. Hydration commences the instant water is introduced into the concrete mix. Freshly mixed concrete is a semi-liquid having a thick, heavy consistency that can be worked and poured like a good cornbread batter. The length of time that concrete remains in this semi-liquid or plastic state is relatively short, generally 2-4 hours. It is during this time, also, that concrete must be worked; i.e., delivered, placed, consolidated, and finished. As time is a limiting factor, the work must be planned, coordinated, and continuous until the job is completed.

GENERAL INFORMATION:

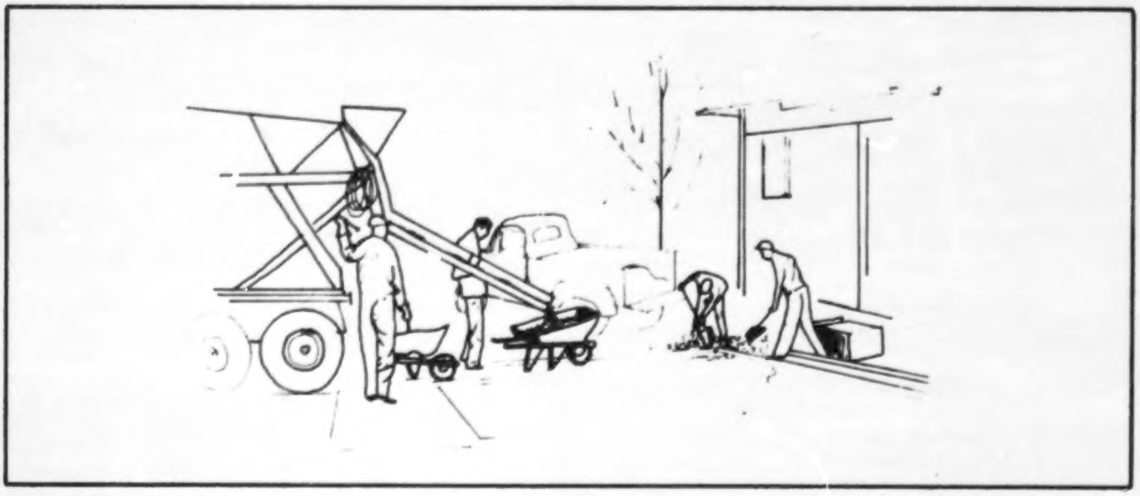
Concrete must be delivered and discharged within 1½ hours from the time water is added to the mixture. It is a good rule-of-thumb to place the concrete within 60 minutes after mixing. This means the job site must be ready to receive the concrete and placement start immediately. Plan ahead! A few simple precautions will insure a quality concrete job and, perhaps, save money.

Allowable time, favorable temperatures, and moisture are the major considerations in placing concrete. There are many methods used to transport and handle the concrete on the job site. Popular methods include the following.

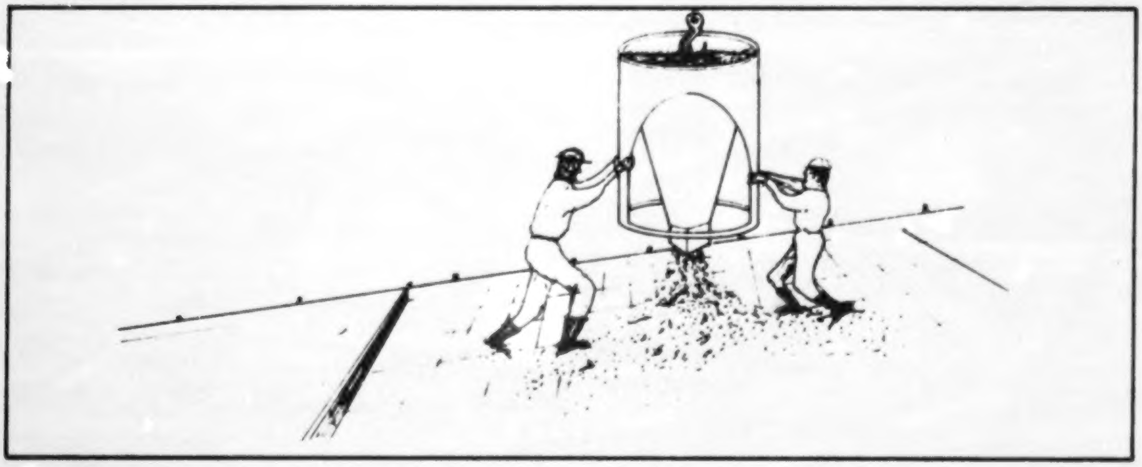
Direct Chuting - is used extensively where mixer trucks can be positioned close enough to the forms to utilize the gravity flow necessary for chuting. The slope of the chute for average mixes (3-5 inch slump) is a ratio approximately 1:3. Direct chuting is one of the most economical means of moving/handling concrete where chuting is feasible--general contracting and homebuilding use direct chuting extensively.



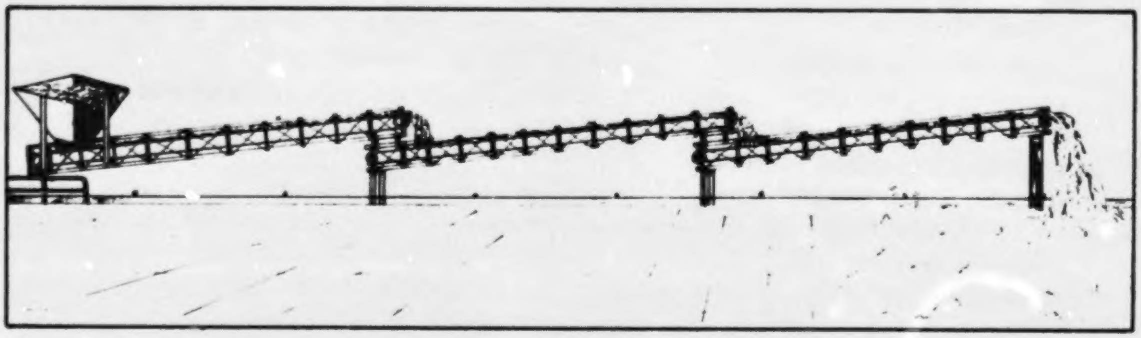
Wheelbarrows and Buggies - are often used on smaller jobs or in conjunction with other types of handling equipment. Buggies and wheelbarrows are excellent for maneuvering through door and passage ways or in enclosed areas where large equipment cannot reach. Drawbacks to this type equipment for handling concrete are: runways are required for smooth operation over formwork and other construction; requires more equipment and manpower to perform work in allowable time.



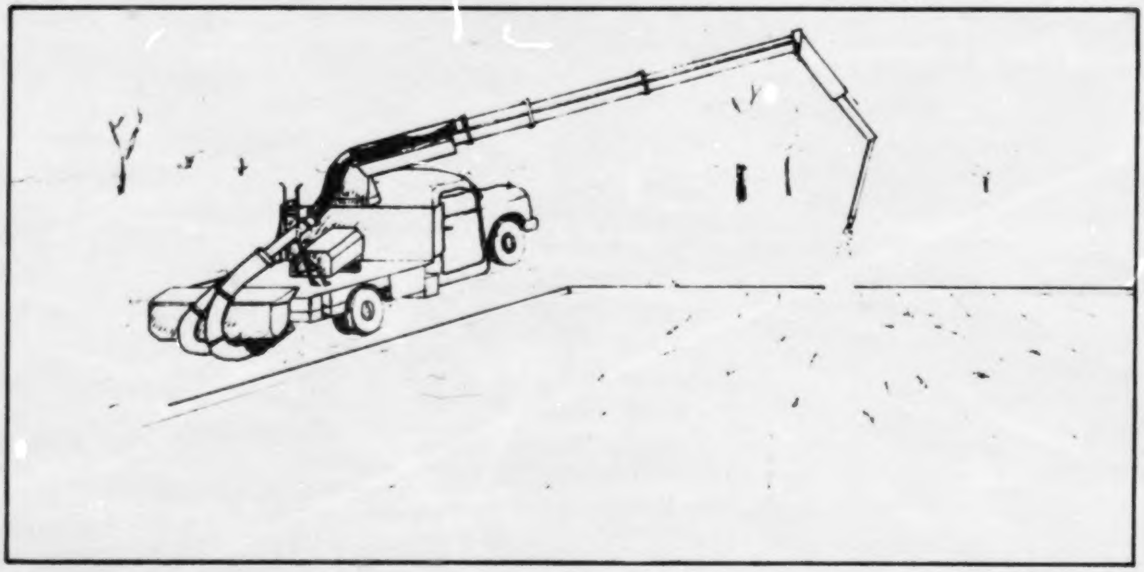
Buckets - are large open-top containers (up to 12 cu. yd. capacity) made especially for handling large quantities of concrete. They are generally in the shape of an inverted cone with a frame built around the outside so as to be self-standing. The concrete is loaded through the open top and released through a gate which forms the bottom or small end of the bucket. The gate may be hand or power operated but allows good control of the concrete as it is discharged. Buckets are moved about with crane hoists and overhead cableways and are used extensively in large, multistory building construction where concrete must be placed in elevated areas. Workers should be particularly cautious when working in areas where heavy moving equipment is operating.



Conveyor Belts - are used to transport large quantities of concrete rapidly and are generally used on large, massive, projects. The most commonly used types are feeder belts, portable belts, and side discharge units and may be used in a combination of types to deliver the concrete to its point of placement. Belt conveyor systems are capable of placing concrete at rates up to 100 cubic yards an hour. Primarily used for dam and bridge construction, they can lay down a ribbon of concrete on large flat areas as well and may prove economical if sufficient quantities of concrete are involved.



Pumping - is the fast growing method of placing concrete. Pumping's flexibility--along with its elimination of rehandling the concrete are its greatest advantages. Pumping is probably the most satisfactory method of moving concrete on the job site. Pumping can be used on small jobs or large ones. In this method of handling, the concrete is pumped under pressure through a system of coupled pipes or hoses that can be laid over, around, or through other obstacles and construction; an added advantage. On production jobs, concrete has been pumped over 1000 feet horizontally and as high as 500 feet vertically. However, the truck pump and boom arrangement can handle most jobs delivering up to 70 cubic yards per hour with a maximum boom available at about 70 feet.

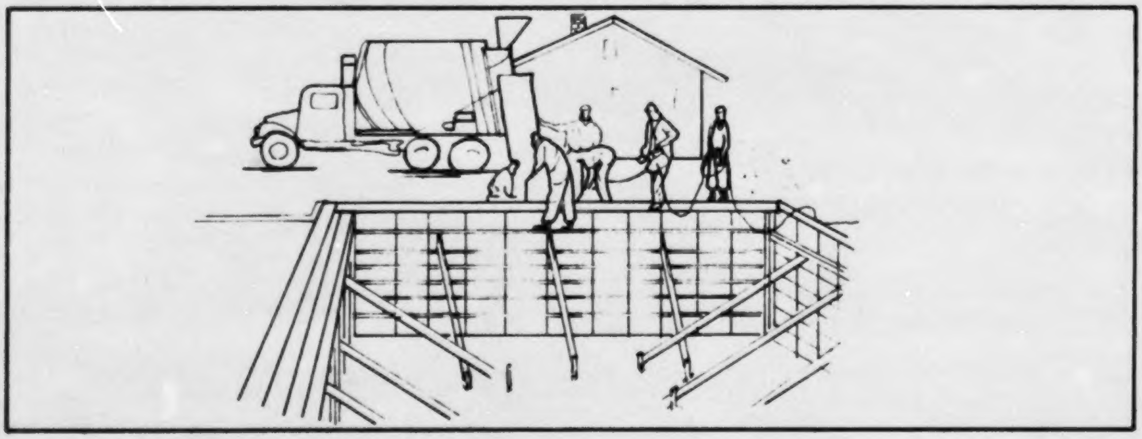


Points To Remember Before Placing Concrete

1. Study the job! The size of the job, type and shape of the structure, its location and accessibility, even the concrete specifications are factors in determining the means of transporting and placing the concrete on the site.
2. Select an appropriate method of handling and placing the concrete based on the above factors, allowable time, and economics.
3. Be prepared with necessary equipment, materials, manpower to handle, place, finish, and cure concrete. Check equipment to be available and in good working order; manpower sufficient to perform work. Anticipate any material needs and have available.
4. On extensive concrete operations obtain weather forecasts. Temperature, weather conditions affect concrete work. Schedule work with favorable weather as much as possible.
5. Check forms to be well braced, properly aligned. Forms should be clean, well oiled for easy removal. Reinforcement should be free of excessive rust and securely tied in place.
6. Schedule work so that the concrete can be placed with the least delay. If screeds are necessary, make sure screeds are set and level with forms.
7. In hot, dry weather, wet down forms and sub-base to prevent absorption of the mix water of the concrete paste. Schedule placement of concrete to take advantage of the cooler evening temperatures.

Points To Remember In Placing Concrete

1. Concrete should be placed, not poured! Concrete should never be dropped freely more than 2-4 feet.
2. Place concrete as close as possible to its final position in the structure. Do not place in small piles and spread.
3. In placing concrete in deep, narrow forms such as foundation walls, columns:
   a. Guide concrete into forms using appropriate type adjustable chutes.
   b. Start at both ends of the form and work toward the middle.
   c. Deposit concrete in level layers 12-18 inches deep--consolidate each layer before preceding to the next.



   d. Fill forms completely after last layer has been consolidated--if wall or column is to support a slab, beam, or girder, allow 2 hours before commencing to pour slab or beams.

4. In placing concrete in shallow flat forms such as slabs and floors:
   a. Start around perimeter at the far end of forms.
   b. Progress work from corners to middle; from far end to near end.
   c. Place each batch against previously placed concrete.
   d. Place concrete as close to final position as possible.
5. In placing, working concrete safely:
   a. Wear appropriate clothing, safety apparel to include eye protectors, rubberized boots, and gloves.
   b. Know location of water curtain, shower, or water hose--wash off any concrete paste that may contact the skin or eyes immediately. Concrete paste allowed to stay in contact with the skin can cause serious burns.
   c. Exercise extreme alertness when working in areas where heavy equipment is operating.
   d. Practice appropriate ladder/scaffold safety while working on elevated forms or in high areas.
   e. Apply proper technique for lifting, carrying heavy objects.

Consolidation

Consolidation - of concrete is the removal of air pockets and voids created in the handling and placing of concrete pastes. Consolidation is generally accomplished in one of three ways; spading, jitterbugging, and vibrating.

Spading - is performed by turning the spade over and with the blade down, executing shallow chopping action over the surface area. Spading is generally used in shallow footings and wall forms.

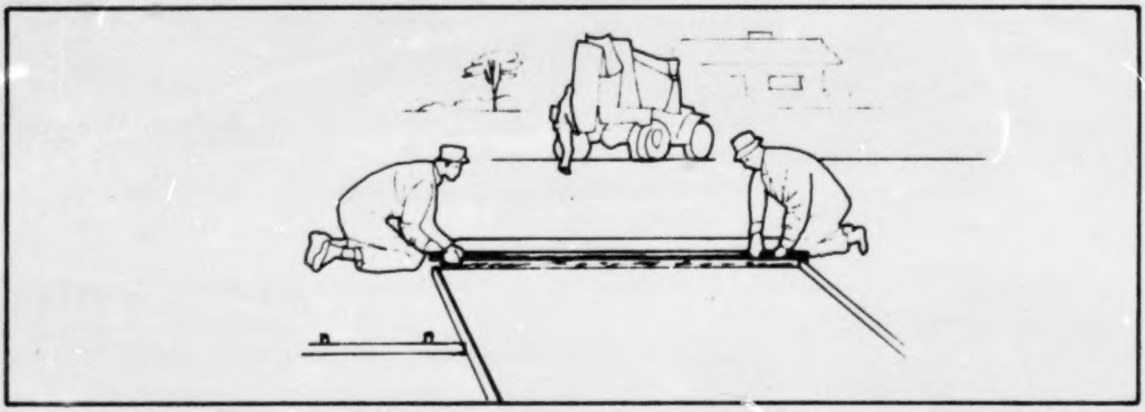
Jitterbugging - is accomplished with a perforated hand tamping tool using a light jogging action over the surface area. Jitterbugging is used on flat areas such as patio slabs, driveways.

Vibrating - is quickly becoming a popular method of consolidating concrete. Vibrators are versatile, quick, and efficient. Internal vibrators, called "spuds," are a stiff but flexible tube to which an electrically operated vibrating head is attached. The head is immersed in the concrete paste at predetermined intervals, generally 10-12 inches, and high frequency vibration quickly consolidates the paste. The spud is then removed and repositioned. The motion is almost a slow jabbing action. Proper consolidation provides a tighter, denser, stronger paste.

Finishing

Finishing - is the treatment of concrete surfaces to produce a desired texture and wearing qualities. All concrete surfaces require finishing to some extent. After the concrete is placed, it is struck-off to remove all the humps and hollows that result from placement.

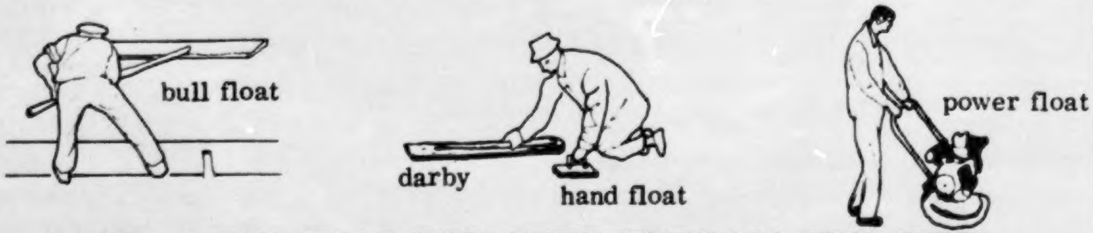
Strike-off, - also called screeding, is performed with a straight edge or strike-off board placed across the tops of the forms and/or screeds and moved back and forth in a sawlike action, advancing the board a short distance with each stroke. This provides an overall true, even surface to the concrete. After striking-off, the screeds, if any, are removed and the holes patched. The concrete is now ready to float.



Floating - eliminates the minor ridges and/or voids that may be left after the strike-off operation. Floating also helps push larger aggregate down and bring sufficient mortar to the top. A good float finish often serves as the final finish. There are several different types of floats; generally the size and type of job dictates the type of float used.

Bull Floats - are large hand floats 6"-8" wide x 4'-6' long with a long (8'-12') handle attached to the center of the back and extending to one side at about a 15° angle with the float face. Bull floats are used on surfaces of moderate size such as double driveways, large patios, foundation slabs for moderate sized homes and buildings. Bull floating is performed using long, gentle push/pull strokes while raising the lead edge of the float slightly. The weight of the float is generally sufficient to smooth and blend the surface.

Darbies - are large hand floats 3"-4" wide x 4' long with an elongated, tapered handle along the top of the back. This float is used on surfaces of moderate size that can be reached by hand and in areas where the long handle on bull floats restricts their use. Darbying is performed using long, gentle, sweeping strokes and raising the lead edge slightly to smooth and blend the surface concrete.



NOTE: A GOOD FLOAT FINISH OFTEN SERVES AS A FINAL FINISH

Hand Floats - come in many types and sizes. Most are 3"-4" wide x 12"-16" long with a handle on top of the back. Hand floats are used primarily to smooth and finish small restricted areas such as in corners, around pipes and columns, and in areas where larger floats cannot reach.

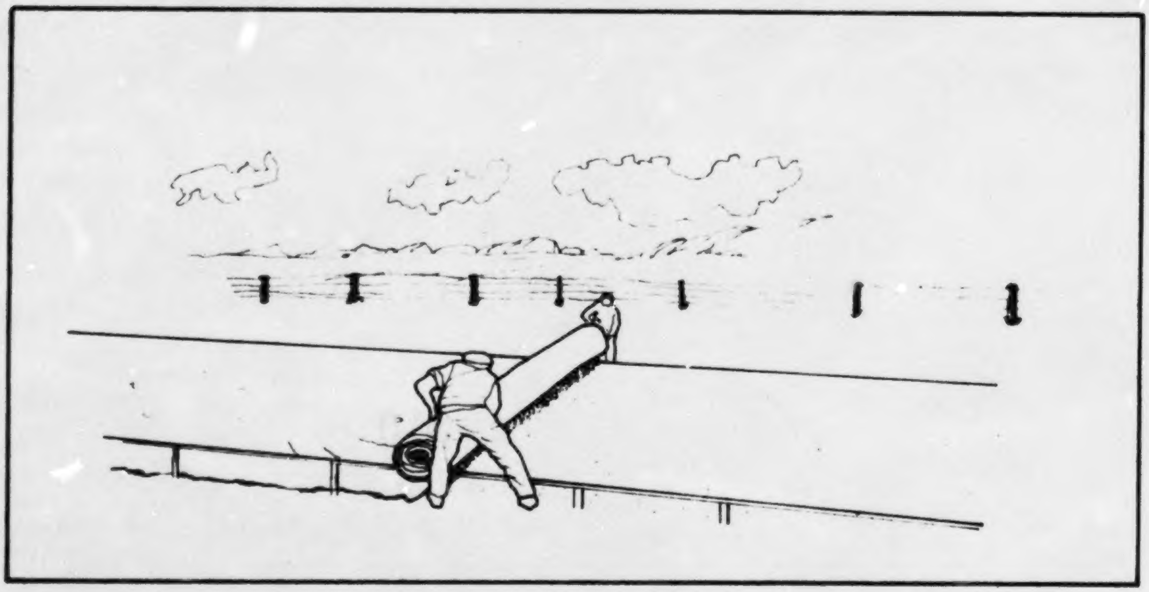
Power Floats - may be gas or electric powered and look and operate similarly to large floor buffers. Power floats perform the same function as hand floating but can cover larger areas faster. Power floats can be used only after the concrete is stiff enough to support the weight of the operator.

Trowels - are available in a variety of sizes and shapes. Each size of hand trowel has a specific purpose. For first troweling, a wide trowel 16"-20" long is generally used; for final troweling, a fanning trowel 14"-16" wide is preferred. Power trowels have 3 or 4 rotating steel trowel blades powered by an electric or a gasoline engine. The use of trowels gives concrete surfaces a dense, smooth surface.

Curing

Concrete is cured by a chemical process between cement and water called hydration. If water evaporates from the concrete paste too rapidly, it will cause the concrete to check (crack) and otherwise be weakened. Proper curing is an important factor in obtaining good concrete. Proper curing requires time, favorable temperatures, and moisture. Anything we can do to improve these conditions is called curing. As time cannot be altered, and since concrete should not be placed in extreme weather, the prevention of too rapid loss of moisture is the condition we can best control. There are two major classifications of methods used for this purpose.

1. Those methods which prevent the loss of moisture--these include watertight covers and chemical membranes.
2. Those methods which supply additional moisture such as water retaining covers, sprinkling, and ponding.



Points To Remember For Curing Concrete

1. Be prepared with necessary cover material and equipment well in advance. Use sheets as wide as possible to reduce the amount of seams that must be sealed. Have plenty of boards to hold sheets in place and seal the edges. If sprinklers are used, test to make sure sprinklers are functional and coverage is sufficient. If ponding is used, have dykes prepared and insure ample water supply.
2. Dampen sub-base and forms thoroughly before concrete is placed so that the ground and forms do not absorb water from the concrete.
3. Schedule work to take advantage of conditions - cool of evening on hot days; warmth of mid-day in cold weather.
4. Start curing as soon as concrete surface is hard enough to resist marring.
5. Continue curing for at least three days and preferably seven days.
6. If method supplies additional moisture - keep constantly moist. Do not allow a wetting/drying action.

INSTRUCTOR'S PLAN
MANIPULATIVE LESSON

II-G-1(S)

TASK: Place And Finish Concrete — Monolithic Slab And Beam Foundation

AIM: The students will be able to place and work concrete paste as necessary to finish a monolithic slab and beam foundation according to plans and specifications

TOOLS AND EQUIPMENT: Wheelbarrows, shovels, "spud" vibrator, jitterbug, strike-off board, bull float, darby, power float, hand floats (2)
Optional: power trowel, hand trowels, edger

MATERIALS: Concrete (paste) — type and quantity as per plans and specifications

REFERENCES: Modern Carpentry, pp. 91-102
Concrete Technology, Units 12, 13, 14

PREREQUISITE EXPERIENCE OF THE LEARNER: The student must have successfully completed previous lessons II-G-1(I), "Cement/Concrete"; II-G-2(I), "Concrete Mixes And Mixing"; and II-G-3(I), "Placing, Finishing, Curing Concrete"

CHECKING STANDARDS:

1. Follows acceptable procedures:
    - a. placement
    - b. consolidation
    - c. strike-off
2. Work habits; attitudes
3. Efficient use of time; energy

I. PREPARATION (OF THE LEARNER - MOTIVATION)

The old adage, "Good concrete is placed, not poured", is very true. The job of placing and finishing concrete should be thought out in advance and everything made ready to start the job upon arrival of the concrete — the forms, moisture barrier, and reinforcing steel set and in place; the tools and equipment for transporting and working the paste available and in good working condition; and the procedure for placing and finishing the concrete determined and work assignments made. Even the weather should be considered in scheduling time of concrete delivery and estimated length of job. Once the concrete is delivered, the work should be continuous until the concrete is placed and finished.

II. PRESENTATION (OF THE SKILLS)

STEPS	KEY POINTS (THINGS TO REMEMBER TO DO OR SAY)
1. Plan Job Procedure	1. Method of transporting paste on site 2. Method of placing paste 3. Starting point of placement

4. Direction and progression of placement
5. Tools and equipment sufficient to perform job, tasks
6. Manpower available — assignments made

2. Place Concrete
   1. Start at far end and work toward near end
      a. Use direct chuting where possible
      b. Use wheelbarrows, buggies where necessary
   2. Fill corners first and work toward middle
      a. Fill beams and slab simultaneously
      b. Place concrete as close to its final resting place as possible
      c. Place each batch against previously placed concrete

3. Consolidate Concrete
   1. As placement progresses
   2. Use spud vibrators in beam areas; around forms
      a. Insert spud to approximate beam depth
      b. With steady up-and-down motions
      c. Throughout beam areas
   3. Use jitterbug tool in slab areas
      a. Jogging action throughout
      b. Consolidates, helps level paste

4. Strike-off Concrete
   1. As placement and consolidation progress
   2. Start at far end
   3. Use strike-off board or tool
      a. Place across form boards and/or screeds
      b. Move back and forth in a saw-like action
      c. Advance the lead edge a short distance with each stroke
      d. Keep small amount of paste ahead of straightedge to fill low spots and maintain the surface plane after strike-off

5. Initial Float
   1. Must follow immediately after strike-off operation
   2. Before any free water bleeds to the surface
   3. Is accomplished by bull floating and/or darbying
   4. Acts as a second leveling operation
      a. To remove minor ridges, voids left by striking-off
      b. Helps push larger aggregate down; bring sufficient mortar to top

A. Bull Float

1. Show example; describe
    a. Large float blade — 1" x 6" x 6' long
    b. Long, 10'-12' handle attached to center back — extends out 90° to one side; extends up at approximate 15° angle
2. Demonstrate use; explain procedure!
    a. Used on large (wide) slabs in open areas
    b. Where bull float can be freely manipulated
    c. Start at far end
    d. Apply long, gentle push/pull strokes from center-to-side of foundation
    e. Raise lead edge of float slightly to prevent gouges; streaks
    f. Allow weight of float to smooth and blend

B. Darby

1. Show example; describe!
    a. Large hand float — 1" x 4" x 4' long
    b. Has elongated, tapered handle along top of back
2. Demonstrate use; explain procedure!
    a. Used on moderate size slabs that can be reached with darby
    b. Used in confined areas where bull float cannot be operated
    c. Place flat surface to concrete with hand centered on handle
    d. Raise lead edge of float slightly
    e. Make large, gentle sweeping strokes with arm extended
    f. Apply light pressure to smooth and blend concrete surface

Note: Avoid overworking concrete surface during initial floating operation

6. Final Float

1. After concrete allowed to harden enough to support man's weight with only slight indentations
2. After surface water sheen disappears
3. Is accomplished with various types, sizes hand floats; power floats
4. Removes slight imperfections, fills small surface voids
5. Often acts as a final surface finish

A. Hand Floats

1. Show examples; describe
   - a. Types — wood, cork, metal blade
   - b. Sizes, shapes
2. Demonstrate use; explain procedure!
   - a. Generally used in pairs — one to support operator's upper body weight; one to do the work
   - b. Use similar as darby except with smaller strokes
   - c. Apply light steady pressure as required to a smooth, dense concrete surface

Note: Hand floats are excellent for working in confined areas — in corners, around pipes and columns

B. Power Float

1. May be gas or electric operated
2. Looks; works similar to large floor buffer except it has four rotary float blades
3. Requires some special training/practice to operate
4. Performs same function as other floats except covers larger areas faster

7. Trowel Concrete

1. Trowel finish produces a dense, smooth surface — slick when wet
2. Seals surface pores — aids in making resistant to rust, stain, freeze

A. Hand Trowel

1. Several types; sizes; shapes
2. Show examples; explain purpose
   - a. Large 16"-20" long trowel — used for first troweling
   - b. 12"-16" fanning trowel — used for final troweling
3. Demonstrate use; explain procedure!
   - a. Place flat surface to concrete
   - b. Raise lead edge slightly
   - c. Use fanning action
   - d. Apply light pressure as required

B. Power Trowels

1. Various types; designs
   - a. May be electric or gas operated
   - b. Works similar to large power buffers
   - c. Has 3 or 4 rotating steel trowel blades
2. Concrete must be stiff enough to support machine and operator

3. Requires some special training/practice to operate
4. Demonstrate operation of power trowel
   - a. Explain operating principles of particular model being demonstrated
   - b. Emphasize safety

8. Special Finish Concrete

1. Jointing; edging
   - a. Purpose and function
   - b. Tools used – show examples
   - c. Demonstrate and explain procedure
2. Decorative finishes
   - a. Types - brushed, raked, burlap
   - b. Demonstrate and explain procedure

9. Cure Concrete

1. Determine method contingent upon:
   - a. Type concrete
   - b. Curing time
   - c. Temperature
   - d. Moisture conditions
2. Obtain all necessary materials for curing in advance such as:
   - a. Polyethylene plastic sheet
   - b. Sand, straw, paper, burlap
   - c. Water, sprinkler system
3. Allow concrete to harden sufficiently to prevent surface damage
4. Apply water retaining covers
5. Keep moisture during curing period

III. APPLICATION (PRACTICE BY LEARNER UNDER CLOSE SUPERVISION)

Students practice placing/finishing concrete on small jobs:
   - a. sidewalk
   - b. porch stoop
   - c. smoking slab or patio
   - d. driveway

Students become familiar with general job procedures; specific tasks
Students practice safety on the job
Students study specific job and tasks; blueprints and specifications
Class establishes job procedure
Instructor makes team assignments

IV. VERIFICATION AND/OR EVALUATION (CHECK ON STUDENT'S ABILITY)

Performance Test!
Students place and finish concrete for a monolithic slab and beam foundation according to blueprints and specifications, job and task sheets.

V. SUMMARY (TELL THE STEPS ON PROCEDURE AS TO WHAT, HOW, AND WHY. REVIEW CHECKING STANDARDS. THIS SUMMARY MAY BE GIVEN AT ANY PLACE IN THE LESSON THE TEACHER FEELS WILL BE PROFITABLE TO THE STUDENTS.)

Concrete starts its chemical reaction, "hydration", the instant water is added to the mix. This means the job site must be ready to receive the concrete upon delivery and work must be continuous and organized until the concrete is placed and finished.

The job should be thought out in advance; a plan of procedure established, the method of transporting and placing concrete determined, and the equipment and manpower available. Even the weather should be considered in planning.

A final check of the site should include: accessways for delivery trucks; clear walks and ramps provided where necessary; forms secure, tight, aligned and level, well braced and oiled for easy removal; reinforcement properly placed and tied.

Upon arrival, the placement of concrete should start immediately at the far end of the forms.

*Place concrete in corners first and work toward middle
*Place each succeeding batch against previously placed concrete
*Place concrete as close to its final resting place as possible
*Work from far end toward near end - fill beams and slabs simultaneously

Consolidate concrete as soon as placement progresses sufficiently. Use spud vibrator around forms and in beam areas; jitterbug in slab(flat) areas. Consolidation should be sufficient to remove any large air pockets or honey combing defects.

Strike-off immediately following consolidation — as placement and consolidation progress:

*Start at far ends of forms
*Place strike-off board on edge across form and/or screed boards
*Work back and forth in a saw-like motion advancing board slightly each stroke
*Keep a small amount of paste ahead of the board to fill low spots and produce a plane surface after strike-off

Floating concrete is accomplished in two stages: (1) initial floating, which is performed immediately after strike-off and before any free water bleeds to the surface by bull floating and/or darbying; and (2) final floating, which is performed after the concrete is allowed to harden sufficiently to support a man's weight leaving only slight indentations. Final floating is accomplished using hand/or power floats. A good float finish is often used as a final finish.

Apply any final finish, troweled or textured, as called for in plans and specifications. When the concrete has hardened sufficiently to prevent surface damage, protective (watertight or water retaining) covers should be put in place and checked regularly during the curing period.

SUGGESTED READING FOR STUDENTS:

Modern Carpentry, Unit 7
Fundamentals of Carpentry, pp. 105-117

THE NEXT LESSON IS: III-A-1(S), "Construct Box Sill On A Footing And Wall Foundation"

II-G-1(J)

JOB SHEET
IN
CONCRETE FOUNDATIONS

NAME OF JOB: Place And Finish Concrete — Monolithic Slab And Beam Foundation

MATERIALS: ASTM C-150, 6 sack mix, 6 gal. paste – quantity as required for job specified, 6 mil polyethylene plastic sheet – as required to cover slab

TOOLS AND EQUIPMENT: Wheelbarrows, spud vibrators, jitterbugs, shovels, bull float, darby, hand float

GENERAL INSTRUCTIONS: The job should be thought out in advance and the site made ready to receive the concrete – the procedure and method of placement predetermined, and the equipment and manpower ready and available. The placement of concrete should commence immediately upon arrival and work should be continuous until the job is complete.

CHECK POINTS: Pre-check job site - ready to place/finish concrete

A. Forms in place - well braced; tight; oiled
B. Reinforcement steel - set; tied
C. Tools and equipment - good working order
D. Manpower - available; know assignments
E. Passageways - clear

PROCEDURE AND/OR TASK:

II-G-1(TS) "Place And Consolidate Concrete"
II-G-1a(TS) "Float Finish Concrete"

CHECK POINTS: Visually inspect finished surface to be smooth and level without surface blemishes

TASK SHEET

II-G-1(TS)

TASK: Place And Consolidate Concrete

JOB: Place And Finish Concrete — Monolithic Slab And Beam Foundation

TRADE: Building Trades

TOOLS AND MATERIALS: Wheelbarrows, spud vibrators, jitterbugs, shovels, ASTM C-150, 6 sack mix, 6 gal. paste concrete, quantity as required

TASK BREAKDOWN:

STEPS	KEY POINTS
CHECK POINTS:	Check: Safety clothing and apparel adequate Location of clean water supply
1. Place Concrete	1. Direct delivery trucks to discharge points 2. Explain plan of procedure to operator a. Use direct chuting where possible b. Use wheelbarrows where necessary 3. Start at far end of foundation forms a. Place in corners first b. Work toward center at far end 4. Work toward near end a. Place each batch against previously placed concrete b. Fill slab and beams simultaneously c. Place concrete as close to its final resting place as possible
2. Consolidate Concrete	1. As placement progresses 2. Start at far end of foundation form 3. With spud vibrator in beam areas and around forms a. With steady down-and-up motion b. Insert vibrating head to approximate depth of beam c. At regular 4"-6" intervals throughout 4. With jitterbug tool in slab areas a. Use light jogging action b. Throughout entire area

TASK SHEET II-G-1a(TS)

TASK: Float Finish Concrete

JOB: Place And Finish Concrete — Monolithic Slab And Beam Foundation

TRADE: Building Trades

TOOLS AND MATERIALS: Bull float, darby, hand floats as required, power float (optional), 3 mil polyethylene plastic cover

TASK BREAKDOWN:

STEPS	KEY POINTS
1. Strike-off Concrete	1. As placement, consolidation progress 2. Start at far end of foundation 3. Place strike-off board/tool across form boards and/or screeds a. On edge b. At far end 4. Move strike-off board back and forth in a saw-like action 5. Advance board slightly with each stroke 6. Keep a small amount of paste ahead of the lead edge of the board a. To fill low spots b. To maintain the surface plane at strike-off Note: A slight jogging action of the strike-off board will help settle large aggregate in the strike-off plane
2. Bull Float Concrete	1. Immediately after strike-off; before any free water bleeds to surface 2. On large (wide) surfaces a. In open areas b. Where bull float can be easily handled 3. As strike-off progresses - start at far end 4. Apply long, gentle push/pull strokes 5. From center-to-side of foundation 6. Raise lead edge of float slightly 7. Allow weight of float to smooth and blend
3. Darby Concrete	1. On smaller surfaces where darby can reach 2. In confined areas where bull float cannot be maneuvered 3. In place of bull floating 4. Place flat on concrete surface 5. Raise lead edge slightly to prevent gouging

STEPS	KEY POINTS
	6. Make large, gentle sweeping strokes to smooth and blend surface
4. Finish Float Concrete	1. After it is allowed to set long enough for water sheen to disappear
	2. When it is firm enough to support a person's weight leaving only slight indentations
A. Remove Screed Boards (If any)	1. Set lag screws in top of boards a. Near forms, each end; or as required b. Allow screw head to stick up 3/4"
	2. Tap screws gently to loosen boards in concrete slightly
	3. Lift boards staright out by screw heads
	4. Set screed stakes in concrete a. Use spare stake as a punch b. Drive flush to bottom of concrete
	5. Fill voids left by screed board a. With thickened concrete paste b. With mason's trowel - fill and smooth
B. Power Float	1. Large, open areas
	2. After having received specific power float instructions and training
	3. Follow all proper operating procedures
	4. Remove surface imperfections, blend and smooth all accessible concrete surfaces
C. Hand Float	1. Edges, in corners, around pipes and columns
	2. Use appropriate size; type floats in pairs: a. One to support upper body weight of the operator b. One to do the actual floating
	3. Place float blade flat on concrete surface
	4. Make smooth fanning type strokes
	5. Apply appropriate pressure to smooth and blend